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CUMBERLAND PLATEAU
SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 5

1 August through 31 October

9 November 1966

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SECTION I

INTRODUCTION

This report reviews the operations and research work conducted by Texas Instruments Incorporated during August, September and October 1966 on the Cumberland Plateau Observatory (CPO) contract. Efforts during the quarter have been directed toward routine observatory operations, Dallas-and station-conducted research tasks and construction and checkout of a detection and identification digital processor.

Operation of CPO during the reporting period has continued on a routine basis. The overall observatory maintenance configuration has remained good with minimum station downtime resulting from a continual preventive maintenance program. Magnetic tape and film data have also been high-quality.

Research activities during this quarter have concentrated on evaluation of the MCF processor, ambient noise studies, detection processor research and a study to improve visual data displays. As in Quarterly Report No. 4*, additional data are presented to demonstrate the increase in station detection capability as a result of on-line MCF processing.

As of 31 October, construction of the auxiliary processor was complete, the basic MCF had been modified to interface with the auxiliary processor and separate checkouts of the two units had been completed. The next phase is to interface the units and conduct system checkout.

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*Texas Instruments Incorporated, 1966: Cumberland Plateau Seismological Observatory, Quarterly Rpt. No. 4, Contract No. AF 33(657)-14648, 28 Oct.

SECTION II

OBSERVATORY OPERATIONS AND RESEARCH

This section presents results concerning CPO station operations and research during the past quarter. Included are the station downtime data for the quarter and reliability information on the MCF processor.

A. STATION ANALYSIS

Station analysis has proceeded on schedule. Data recordings have been good with the only problems being a few instrument failures. Of these problems, the most important was data loss due to inoperability of the long-period Develocorder for four days during October (Subsection IIC-2). The number of events recorded during the quarter are as follows:

Month	Teleseisms	Regionals	Near-Regionals
August	599	8	—
September	635	7	—
October	601	8	2

Included in Section III is a discussion of the number of events reported during August with and without the use of on-line processed data from the MCF.

Of particular interest in the station analysis during the quarter was the Peruvian earthquake of 17 October. During this period at the station, this was the largest event recorded. It has 1049.4 mμ of ground motion and a magnitude 6.3. The direction of the event was SSE from CPO at an epicentral distance of 43°. Table 1 presents the phases reported by station analysts.

B. STATION RESEARCH

Station research during the reporting quarter has been directed primarily toward evaluation of the MCF processor. This has included a study of the increase in detection capability afforded the station by the MCF and a study of the MCF hardware reliability.

C. STATION INSTRUMENTATION

1. General

The station engineering section has continued routine preventive maintenance procedures during the past quarter; however, two problem areas did arise which hampered routine station analysis and operations (Subsection IIC-2). As in the last quarter, routine quality control has also indicated minimal problems with tape and film data during the reporting period (Subsection IID).

Table 1

PHASES RECORDED AT CPO FROM PERUVIAN EARTHQUAKE
17 OCTOBER 1966

Phase	Recording Instrument	Time	Remarks
iP	JMZ	21:50:21.3	compression wave, 1049.4-mu ground motion
eP	LP's	21:50:21.3	
pP	JMZ	21:50:37.2	1.7 second period amplitude 999**
e*	LPZ	21:52:02	
e	JMZ	21:52:46.7	
e	LPZ	21:53:21	
e	LPZ	21:54:11	
e	JMZ	21:56:06.8	
S	LPH	21:56:37	amplitude 999
S	SPH	21:56:39.9	amplitude 999
SS	LPE	21:59:36	amplitude 999
LR	LP's	22:00:51	amplitude 999
e	JMZ	22:01:38.1	
e	JMZ	22:01:50.6	

* e indicates a phase was recorded but not identified.

** Amplitude 999 signifies the phase was clipped.

Another serious problem, failure of the air-conditioning system, was encountered at the station during the quarter but resulted in no loss of data. The system was out on August 28 for replacement of a worn shaft on the heat exchanger and on October 9 when a direct lightning strike destroyed the starting circuit and compressor motor.

Other engineering accomplishments and problems during the quarter were:

<u>August</u>

- No. 4 Develocorder installed at station. This Develocorder will allow output recording from both the MCF and auxiliary processor when they are installed
- A-C power connections on Develocorders standardized
- Tube replaced in Z15 PTA
- Tube replaced in Z12 PTA power supply
- Replaced chemical pump on Develocorder No. 2
- Replaced inlet valves and seals in two chemical pumps
- Maintenance performed on Develocorder No. 2 date-timer
- Adjusted long-period seismometers
- Performance of equalizations and d-c pulses on all systems
- Test calibrations and pulses performed on Z6 and Z7 to check polarity
- Frequency responses on Z1 - Z19, SPN and SPE
- Maintenance on FM discriminator Tape No. 2 to remove d-c offset from output
- Performed d-c pulses on all seismometers
- Weight lifts, pulses and free periods performed on Z1 - Z19, SPN and SPE. G's adjusted on Z4, 7, 9 10, 13, 14, 15, 16, 18 and SPE
- Function generator malfunctioned and was repaired
- Z15 and Z16 damping pots replaced in data line terminal modules
- Maintenance performed on bias oscillator Tapes 1 and 2

2. Major Accomplishments and Problems

Two problem areas did arise which affected station recordings during the reporting period. The first involved the data recorded from Seismometer Z10. The problem was leaking of current in the cable which gave erroneous calibration values. This problem existed during July and August before it was independently discovered through routine FM-tape quality control and through computing calibration analysis in support of the ambient noise studies. The erroneous calibrations affected the absolute level of the single-channel power density spectra for this time period (Subsection IIIB-1). The problem was corrected by replacing bad sections in the cable and by replacing the Z10 data line terminal module which was found to have defective damping pots.

The second major problem area was the loss of data due to the failure of the long-period Develocorders. The Develocorder was inoperative during the following periods for the reasons stated:

- October 18, 15:37 to October 19, 16:25

  Drive motor went out and was repaired

- October 21, 10:38 to 15:40

  Drive motor went out and was repaired

- October 21, 18:05 to October 22, 16:10

  Intermittent work and replacement of shaft

- October 29, 01:37 to 23:36

  Motor was removed and replaced with a spare

Also, during the reporting period, the following minor difficulties were encountered:

- September 22

  Z2 was out for 4 hr for cable splicing

- October 5

  Channel 3 on Tape 1 and Z2 were out for 1-1/3 hr for module maintenance

- October 19

  Z6 was out for 4 hr for cable splicing

September

- Z4 removed from operation to correct sticking mass, repaired, and replaced on-line
- Frequency responses, d-c pulses and equalizations performed on all seismometers
- Performed LPZ maintenance at vault and checked out PTA
- Changed trimpots on channels 9 and 10, Tape 2, and channel 3, Tape 1
- Completed testing and crating of the MCF for shipment to Dallas; unit shipped on 1 October

October

- Data line terminal module box preventive maintenance performed
- All calibration and data cables checked at central recording building for shorts and bad grounds
- Performed maintenance on spare short-period seismometer
- Rewired calibration switching unit
- Preventive maintenance performed on Develocorder No. 1
- Develocorder coding units checked for proper codes and cleaned
- Long-period seismometer adjusted
- Winterizing of long-period seismometers and preventive maintenance of bad spots in cables performed

The removal of the MCF from the station operating configuration on 30 September left unused channels on the Develocorders and magnetic tapes for several outputs. The new trace assignments, as approved by the Project Monitor, are shown in Table 2.

Table 2

DATA FORMAT ASSIGNMENTS

Channel Number	Develocorders				Magnetic-tape Recorders	
	Data Group 6000	Data Group 6032	Data Group 6025	Data Group	Data Group 6017	Data Group 6031
	No. 1 & 2 SP Primary	No. 1 & 2 SP Secondary	No. 3 LP Primary	No. 4	No. 1	No. 2
1	V	V	WI		TCDMG	TCDMG
2	Z7	ΣI	MS		Z1	LPZ
3	Z1	ΣK	ZLL		Z2	LPN
4	Z4	ΣL	NLL		Z3	LPE
5	Z2	ΣT	ELL		Z4	SPN
6	Z3	ΣTF	ZLP		Z5	SPE
7	Z5	ΣD	NLP		Comp.*	Comp.*
8	Z6	ΣE	ELP		Z6	BBZ
9	Z9	ΣH	ML		Z7	ΣD
10	ΣL	ΣG	Z8		Z8	ΣE
11	ΣTF	Z10	WWV		Z9	ΣG
12	ΣT	ZSL	-		Z10	ΣH
13	Z8	Z8	-		ΣTF	ΣT
14	NSP	NSP	-		WWV & Voice	WWV & Voice
15	ESP	ESP	-			
16	WWV	WWV		WWV		

*Compensation

3. MCF Maintenance and Reliability

Required maintenance effort on the MCF processor has been minimal during the reported quarter. The major engineering effort expended on the MCF has been directed toward solution of the coefficient loss problem. The probable cause of this problem has been identified, and a modification was designed, installed and tested in the unit. Results of these tests indicated that the modification is suitable.

a. Hardware Reliability

MCF reliability data for August and September* indicate that the unit was inoperative less than 0.01 percent of the total operating time. This includes downtime for routine, preventive and unscheduled maintenance. No component replacements, which would affect the MCF basic performance, were required during this period.**

A meaningful maintenance and reliability guide which is used in judging hardware performance is the "meantime between failure" (MTBF). The MTBF for the MCF has been computed with the following results:

- MTBF of 429.8 hr for the period 18 March 1966 to 30 September 1966
- MTBF of 900.0 hr for the period 19 May 1966 to 30 September 1966 (i.e., period following "infant mortality")***

It should be noted that, in computing MTBF data, only those component failures and other maintenance problems which directly affect basic operation of the hardware as an MCF are considered. Thus, problems which might exist in the paper tape reader, printer and blower system would not affect the MTBF.

The MTBF of 900 hr after the infant mortality period means that on the average a component failure or other maintenance problem could be anticipated at 37.5-day intervals. This is somewhat above the original theoretically derived result of 277 hr. MTBF data on the MCF will continue to be updated when the MCF is returned to on-line operation at CPO. Similar data will be compiled for the auxiliary processor.

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* Data for October are not available since the processor was returned to Dallas on 1 October for auxiliary processor retrofit and checkout.

** The paper tape reader did require some part replacement and maintenance, but this unit does not affect the MCF basic routines or outputs.

*** The "infant mortality" period was chosen as 2000 hr and is normally considered the "shakedown" period in which marginal and bad components are identified and replaced and other maintenance problems normally appearing in new equipment are corrected.

b. Coefficient Loss Problem

Since the installation of the MCF at CPO in March 1966, there has been a sporadic loss of filter coefficients which theoretically would void the output of the affected channel. Such a loss should not occur in the hardware under operating conditions which normally exist at a remote observatory.* Considerable effort has been directed toward determining the problem cause. Identification of such a problem is difficult since the chance of isolating the conditions which might effect a loss is reduced due to the sporadic nature of occurrence and to the extremely short time periods (2 to 200-μsec range) in which the loss could occur. Initial efforts were directed toward insuring that the MCF was operating as designed. This was accomplished by replacing several marginal and bad components in May 1966.** The internal and station electrical ground paths were changed to insure that ground-loop problems, which could cause a coefficient loss, did not exist.

Since data collected under conditions existing at the time of a coefficient loss indicated a strong correlation of loss to local electrical storms, an attempt was made to simulate conditions, similar to those which might exist during such storms, on the MCF power and data line inputs. Over-voltage placed on the line had no effect on loss. However, when a power dropout of short duration (approximately 5 msec) was created on the input power line, a 50-percent occurrence of coefficient loss was obtained.

Further investigation revealed that the short duration line power dropout could cause a marginal +4-v logic power supply which would be too brief to be detected by the memory data-save. The marginal logic supply could then cause a dropout or miscount on logic commands to the memory which would affect the memory read/write routine, thus creating a coefficient loss. A modification has been incorporated into the MCF to avoid this condition. The modification monitors the +4-v supply and places the MCF in "stop" during short-duration transients which were not previously detected by memory data-save. The minimum time the unit is required by this circuit to remain in "stop" is 100 msec, or two frame times. Laboratory tests have shown that the addition of this modification prevents coefficient losses resulting from short transients. The next evaluation phase of the modification will be on-line testing at CPO which will begin in January. The modification will also be tested for a no-delay condition to determine if the 100-msec delay requirement can be deleted.

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* Specification for Advanced Multichannel Filter 563992-2, TI Drawing No. 555702, 3 June 1965, paragraph 3.3.5.3.5.

** Texas Instruments Incorporated, 1966: Cumberland Plateau Seismological Observatory, Quarterly Rpt. No. 4, Contract No. AF 33(657)-14648, 28 Oct.

A more detailed discussion of the coefficient loss problem and the modification is provided in Appendix A along with a discussion of the effect that coefficient losses have on MCF output data.

D. QUALITY CONTROL

Routine quality control procedures for FM magnetic tape Develocorder film data have continued on a spot-check basis throughout the recording period as outlined in previous reports.* Results of this effort have been beneficial in determining problems which existed with the FM tape data and station instrumentation.

Generally, the quality of the film data has been good, primarily as a result of the Develocorder overhaul program (discussed in CPO Quarterly Report No. 4). Analysis form completion has been accurate and neat, and the only real problem encountered on the film data was as a result of the LP Develocorder failure which was discussed under station instrumentation.

During the period reported, magnetic tape data were in good overall condition. The tapes appeared serviceable, and very few spikes were observed during the tape spot-checks. The results of the QC effort for the period are summarized below:

- Wow and flutter consistency within tolerance on both transports
- VTC was consistently good, but on occasion WWV was noisy, probably due to radio interference
- VTC and WWV were aligned in time on all records checked
- Average frequency measurements showed all channels to be within tolerance of center frequency, with the exception of Channel 13 on run C6-233-1. This was immediately corrected.
- Tape calibration checks were within tolerance
- Seismometer calibration checks pointed out the problem with Z10 which is discussed under Subsection IIC

*Texas Instruments Incorporated, 1965: Cumberland Plateau Seismological Observatory, Quarterly Rpt. No. 1, Contract AF 33(657)-14648, Aug. 8, p. II-7.

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SECTION III

RESEARCH

A. GENERAL

This section reviews the research performed on the CPO contract during the reported quarter. The research activity is divided into four areas and is basically oriented toward improvement of station detection capability. These areas are the continuation of the ambient noise study, the auxiliary processor, an MCF evaluation study, and a study of visual data display improvement. A general description of each of these tasks follows.

- Continuation of Ambient Noise Study

  The purpose of this task is to insure time-stationarity of the major contributors to the CPO organized ambient noise field. This task is studied through the computation of single-channel power density spectra and multi-dimensional frequency-wavenumber spectra.

- Auxiliary Processor

  This task includes the design and construction of a real-time detection and identification processor which interfaces with the existing MCF. The task includes research on the operating parameters of the processor and an evaluation of the effects on the output data of assumptions used in the processes. Once the processor is operating on-line, an evaluation of its effectiveness as a detection tool will be conducted.

- MCF Evaluation Study

  This study is being performed to determine the increase in detection capability in analysis work afforded the station personnel through the use of the MCF. As was outlined in Quarterly Report No. 4*, this task is being accomplished through the compilation and analysis of two lists of events.

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* Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.

These lists are studied to compare the number of events reported with and without the use of MCF data in routine analysis.

- Visual Data Display

  Various methods for improving visual data display will be developed and evaluated under this task. Ultimately, techniques will be recommended to improve analyst use of film data. Two approaches being investigated at present are the design of single-channel filters to remove the system amplitude and velocity responses and the processing of CPO data through various playback techniques to improve the display features.

B. AMBIENT NOISE STUDY

This subsection compares the properties of the present CPO noise field with those noted previously (May 1965 to July 1966) to ascertain if the noise field, as previously modeled, has changed enough to affect the performance output of the MCF coefficients. Since May 1966 this study has included the computation of one single-channel power density spectra per week and one multidimensional frequency-wavenumber spectra per month. The study will continue on this schedule through April 1967.

1. Single-Channel Power Density Spectra

At present, the data for this study have been processed through August, with the September data currently being analyzed. As mentioned in Section II, the calibrations to channel Z10 during the months of July and August, as reported on the daily calibration logs, were incorrect due to cable and instrumentation problems, and accurate absolute ground-motion levels could not be placed on the spectra. However, the shape of the spectra is correct and can be analyzed for changes in spectral shape or predominate features.

The single-channel power density spectra for the months of July 1966 and August 1966 are shown in Figures III-1 and III-2, respectively. The general shapes of these spectra do not differ appreciably from those presented in CPO Quarterly Report No. 3*. However, of particular interest

* Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 3, Contract AF 33(657)-14648, 29 Mar.

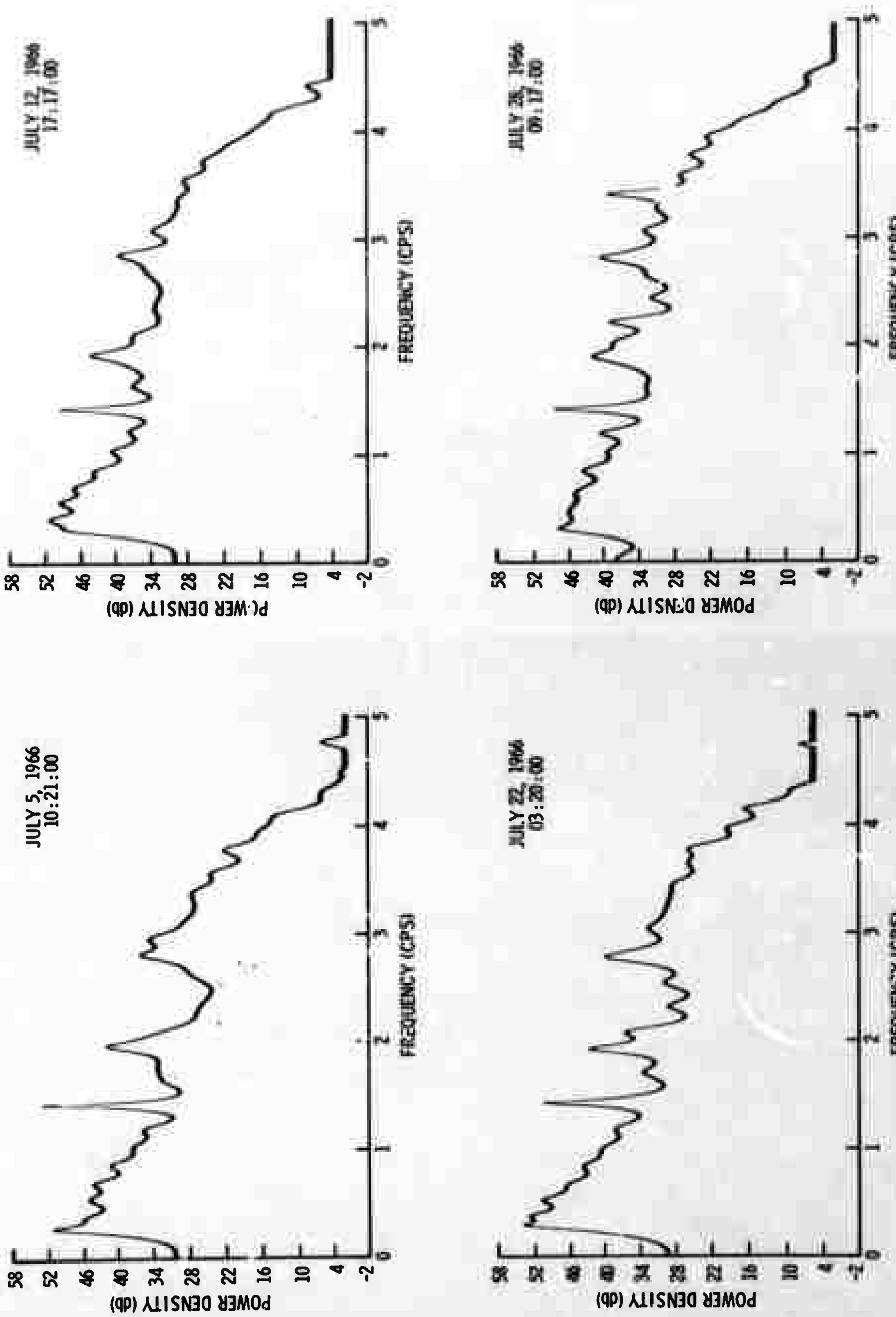

Figure III-1. CPO Ambient Noise Power-Density Spectra for July 1966

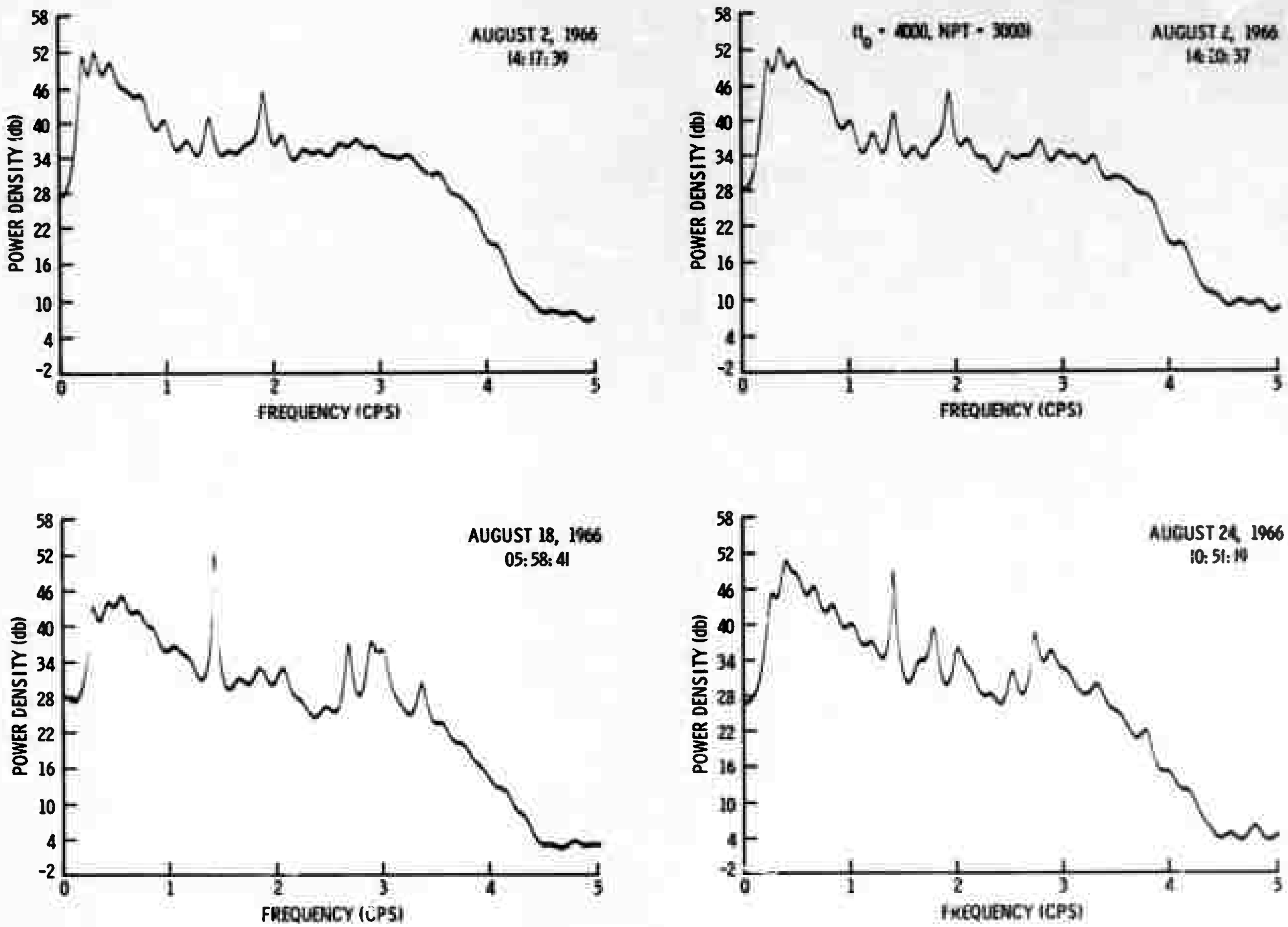

Figure III-2. CPO Ambient Noise Power-Density Spectra for August 1966

is the high level of the peaks at 1.4 cps, as shown in the spectra for July 5 and August 18. This peak is approximately 24 db above the average noise level for these days, while the highest level shown in CPO Quarterly Report No. 3* on 13 August 1965 is 15 db above a comparable level.

Although this result would tend to indicate a change in the noise field, such a conclusion is unwarranted since this peak has been observed before and varies considerably in level. Further discussion of the 1.4-cps peak is presented under the section dealing with f-$\vec{k}$ spectra.

2. Frequency-Wavenumber Spectra

The data presented in the 3-dimensional frequency-wavenumber spectra in Figures III-3 through III-7 for 5 July 1966 and 18 August 1966 do not differ significantly from those presented in previous quarterly reports, thus indicating time-stationarity of major organized noise-field contributors.

Of particular interest during the reporting period are the spectra for 10 August which were specially computed at 1.4 cps because of the predominance of energy at this frequency (Figure III-6). The strongest noise contributor originates north of the station and propagates with an apparent horizontal velocity of approximately 5 km/sec. The most striking feature of these spectra is the manner in which they are highly peaked as opposed to peaks in other spectra which are less well-defined, indicating probable spatial organization of this component. Previous spatial prediction filtering results have shown this energy to be organized. Thus far, tests to determine the exact cause of the 1.4-cps contributor have been inconclusive. It has been postulated, due to the apparent dependence of peak level upon rainfall, that the cause may be the many streams and rivers north of the observatory.

3. Conclusions

Results presented in this section show that the ambient noise field, as described by single-channel power density spectra and frequency-wavenumber spectra, has not changed significantly from the field modeled in the previous contract year. The same major organized contributors to the field consistently appear in f-$\vec{k}$ space, and the single-channel spectral shape is remaining constant. Therefore, the filters developed previously for use in the DMCF appear to be accurate for normal noise days. As was discussed in CPO Quarterly Report No. 4**, the f-$\vec{k}$ method of investigating

* Ibid

** Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.

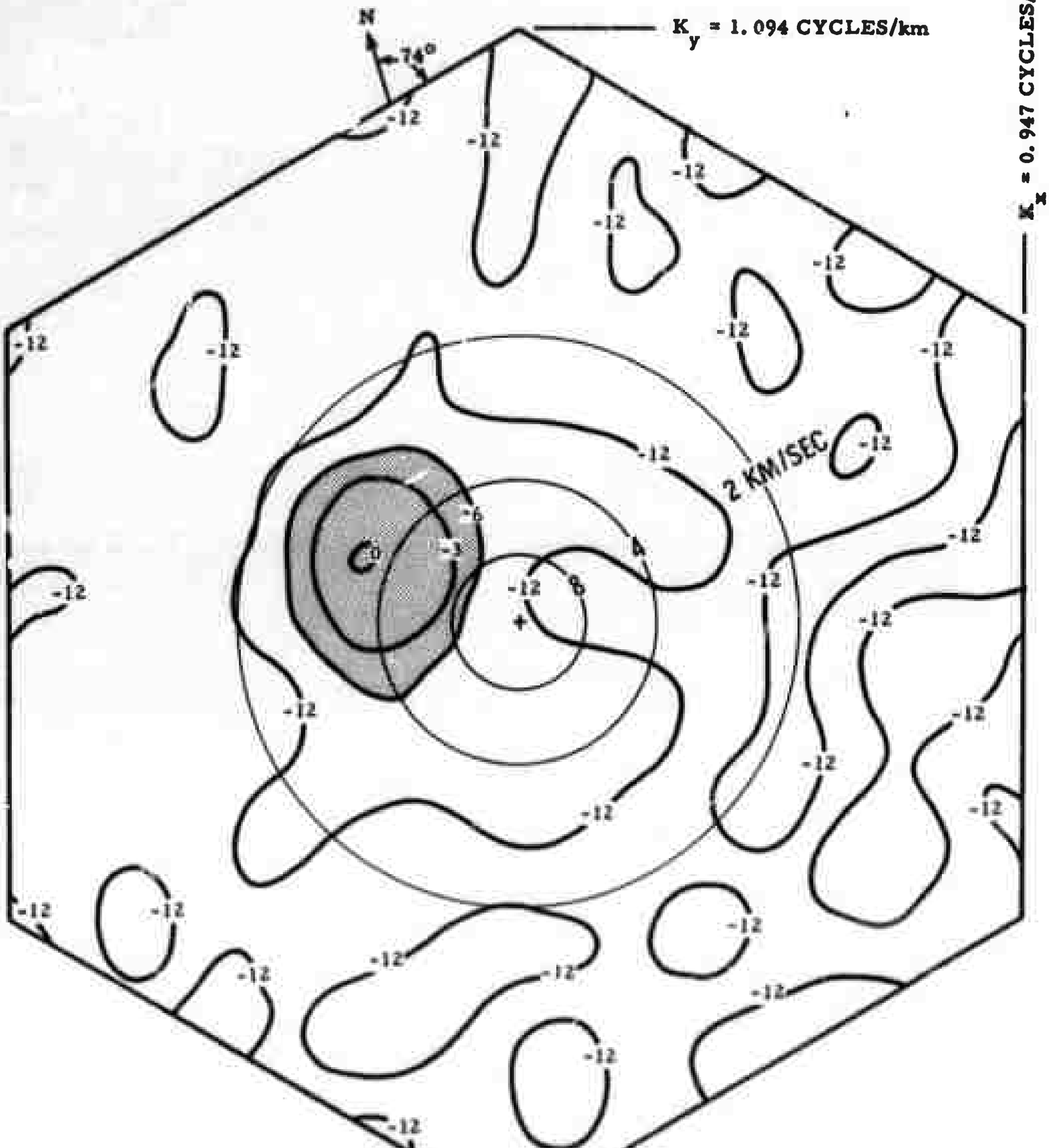

Figure III-3. CPO Ambient Noise Frequency-Wavenumber Spectrum 5 July 1966 (f = 1.00 cps)

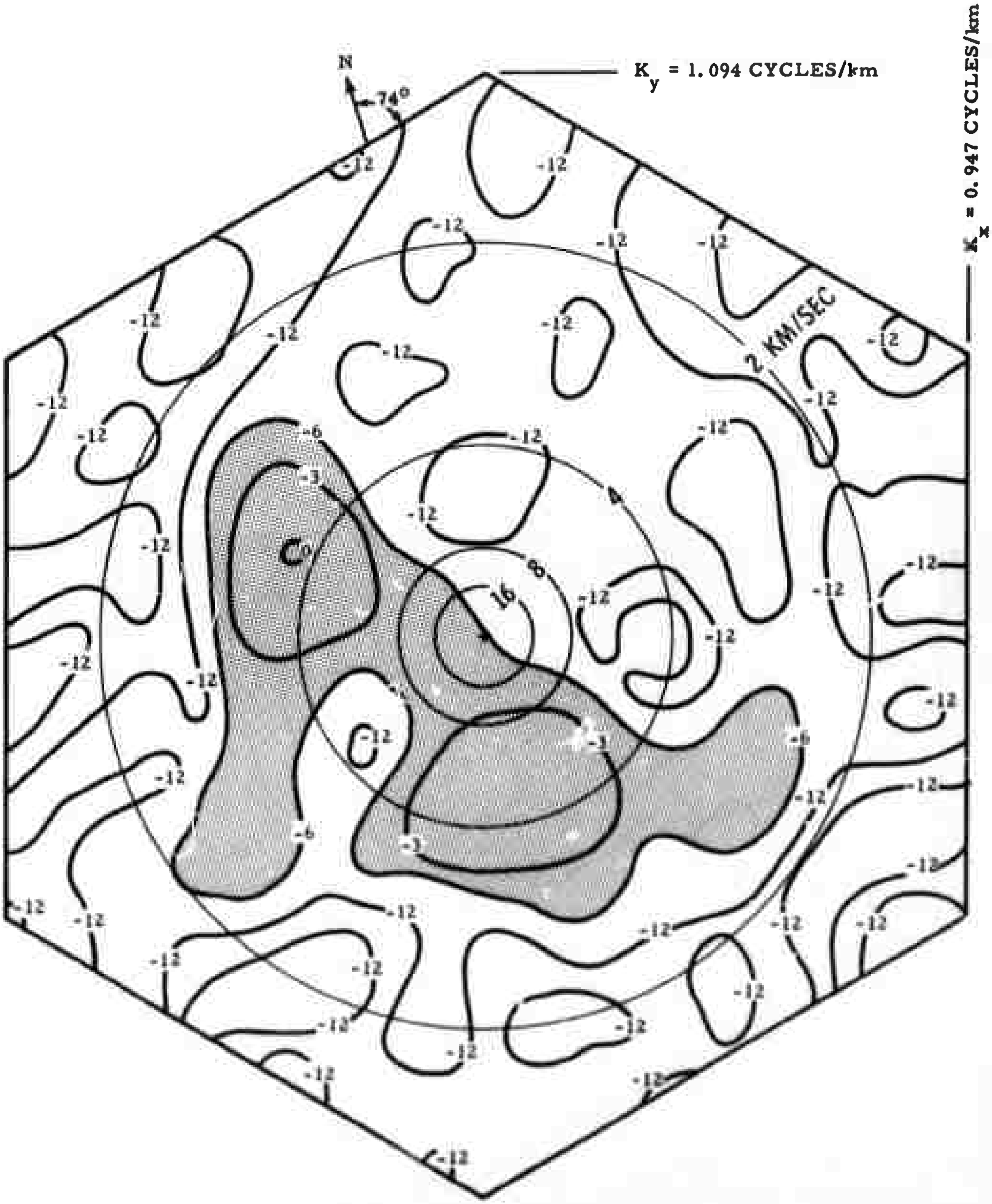

Figure III-4. CPO Ambient Noise Frequency-Wavenumber Spectrum, 5 [illegible] 1966 (f = 1.50 cps)

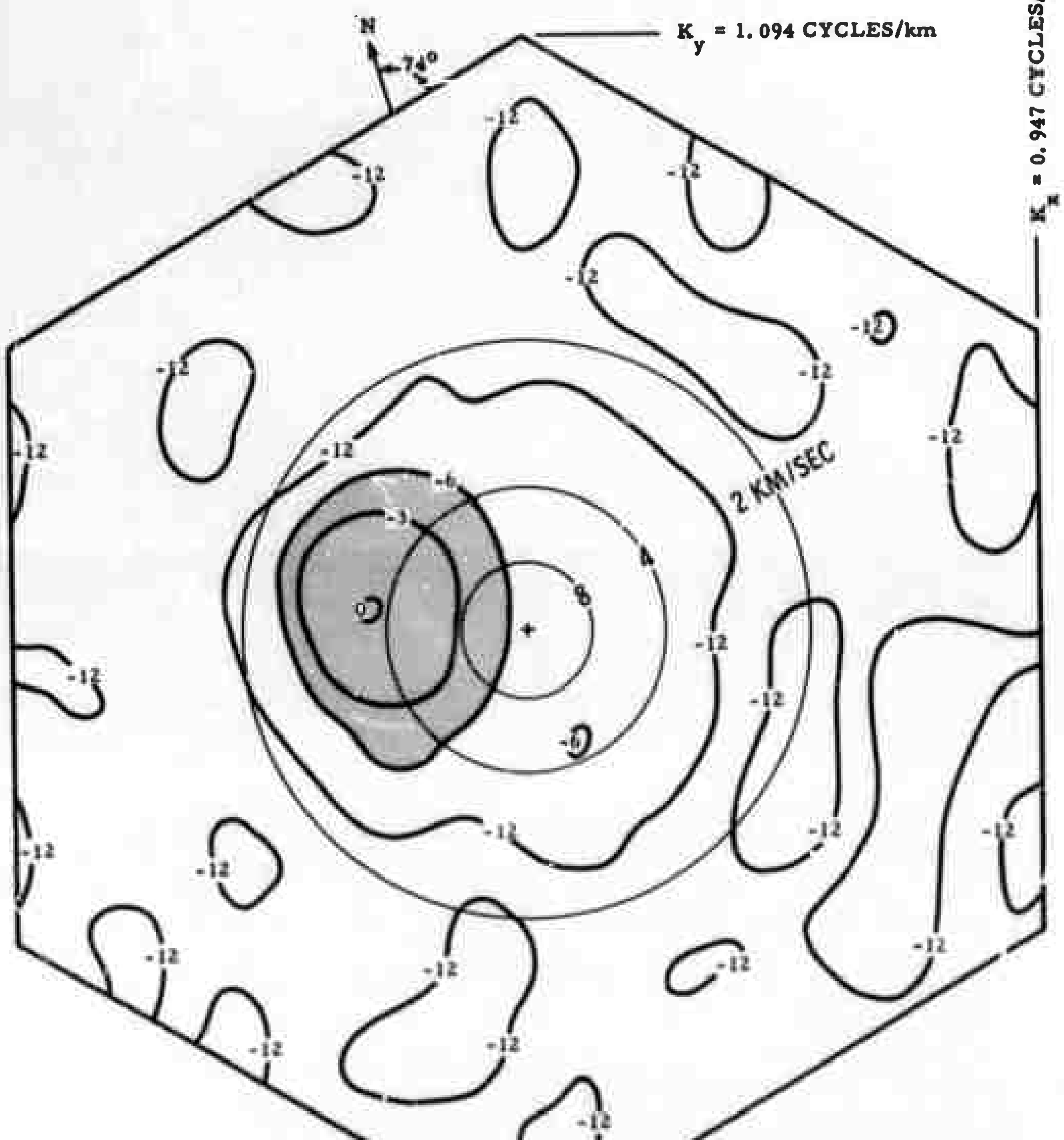

Figure III-5. CPO Ambient Noise Frequency-Wavenumber Spectrum, 18 August 1966 (f= 1.00 cps)

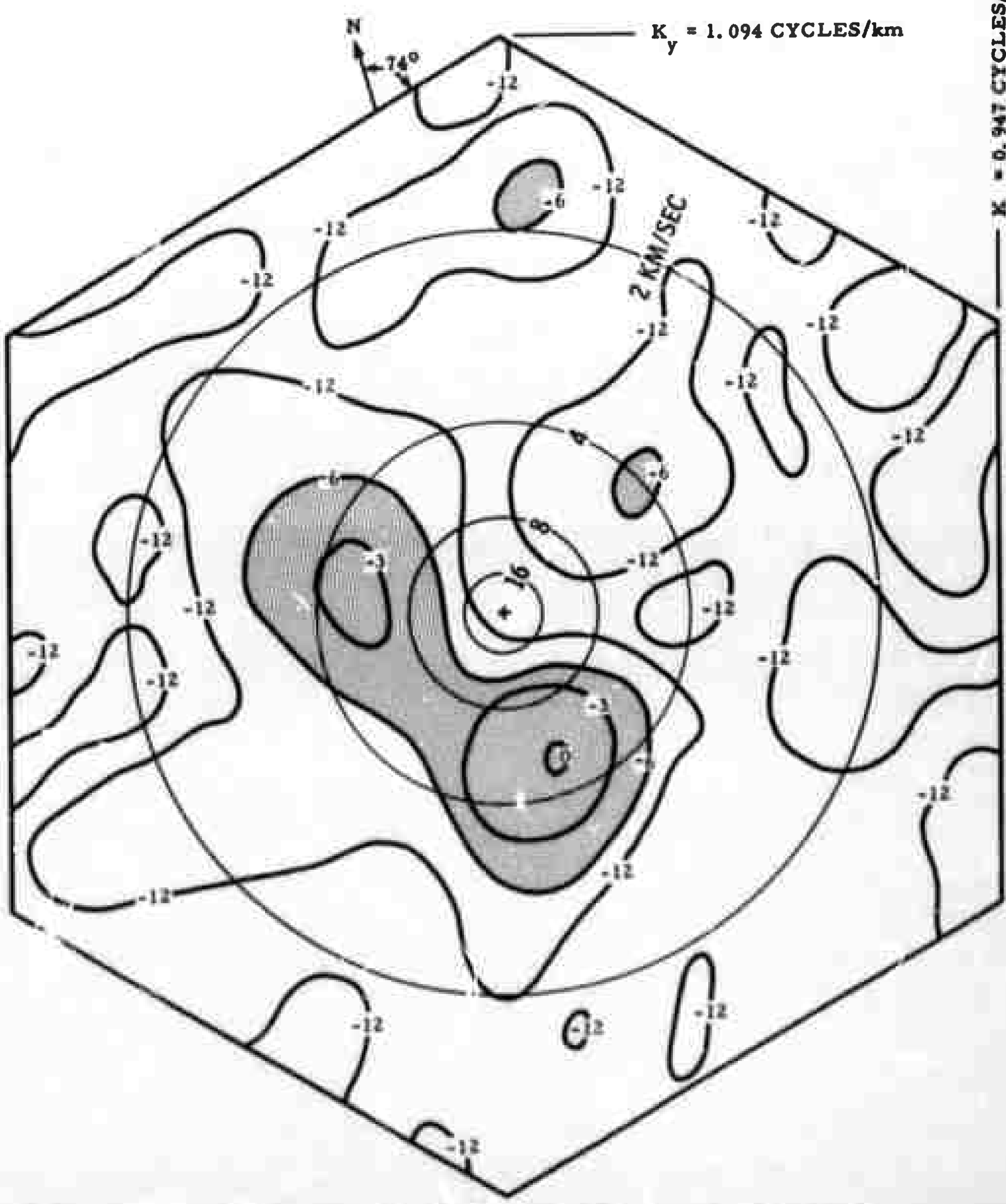

Figure III-6. CPO Ambient Noise Frequency-Wavenumber Spectrum, 18 August 1966, (f = 1.40 cps)

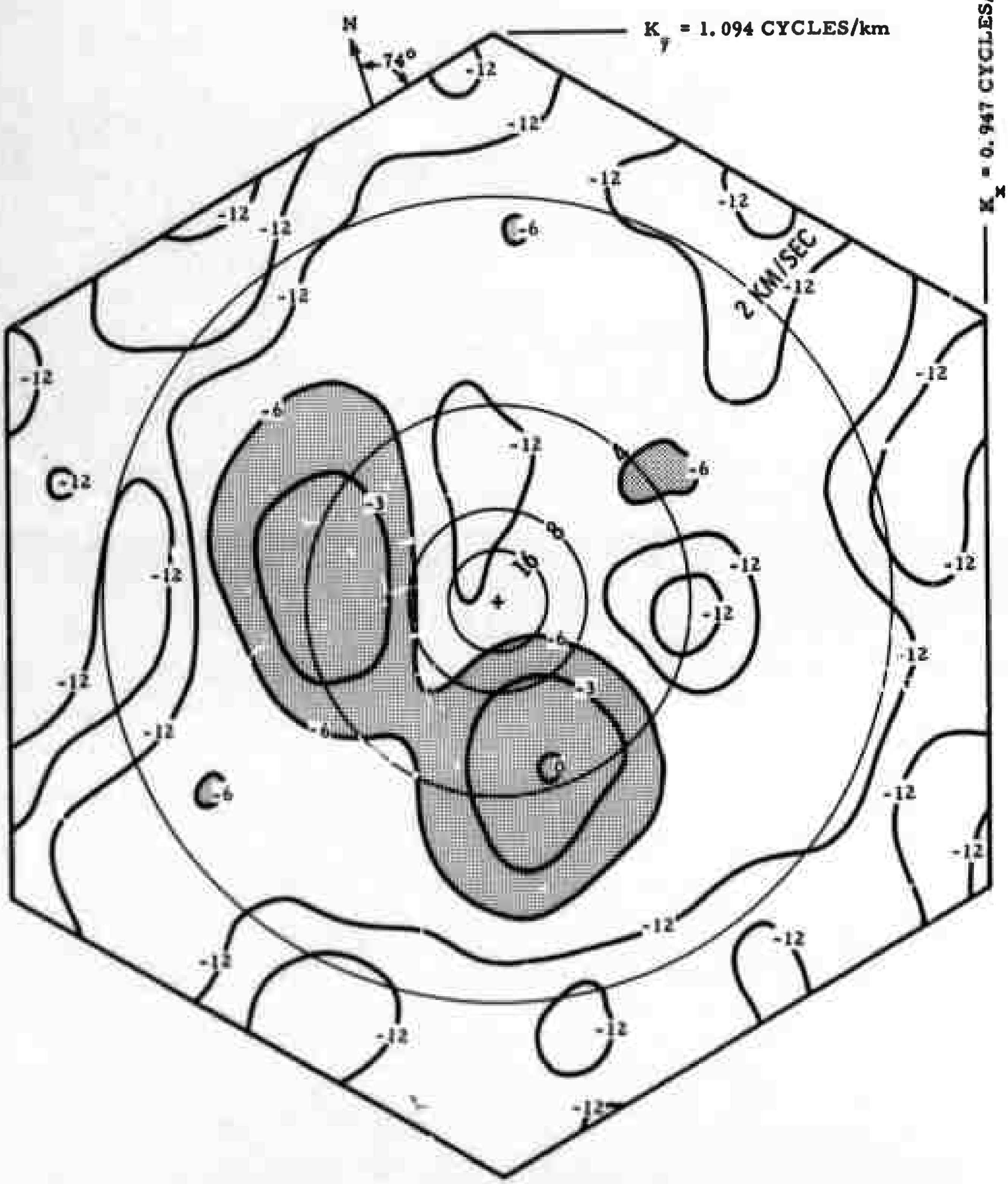

Figure III-7. CPO Ambient Ncise Frequency-Wavenumber Spectrum, 18 August 1966 (f = 1.50 cps)

noise-field properties is limited to the study of major properties due to spectral-window considerations and plane-wave assumptions.

C. AUXILIARY PROCESSOR

1. General

This task includes the design, construction, installation, and evaluation of an auxiliary processor capable of computing on-line Wiener, Fisher, and UK statistics. The unit will be interfaced with the MCF and operated on-line at CPO. Research for this task includes the development of a simulation program to verify the processor logic, to evaluate truncation errors introduced in the processor at various points, and to determine the operating parameters which will be used in the processor when it is installed on-line. Work will also include an investigation to determine the effects on the Fisher and UK processes of violations of the assumption that the ambient noise field is random. The CPO ambient noise field does not meet this condition in the frequency band of interest.

2. Detection Processing Research

This task has been initially directed toward writing a simulation program of the processor. During the reporting period, the program was completed and was used to test the processor logic. This was accomplished by running test tapes through the processor and checking the output against the known test outputs. Results of this study showed that the processor logic was correct and that the processor computed the Fisher, UK and Wiener outputs as expected. Additionally, the program input-output subroutines were modified to handle real data which could be input on IBM magnetic tape.

Results of processing actual CPO data through the processor simulation program were to be published in this report; however, operational problems have delayed this processing. When these problems are solved, plans are to process several CPO events and noise samples through the program, determining the effects of each of the processing techniques on actual CPO data. These results will be used to determine the operating parameters to be used in the processor when it is installed on-line at CPO.

Data, which have been selected for processing using this program, were collected at CPO during 1963 from the 19-channel short-period array. Four samples, teleseisms AA, BB, and CC and nuclear blast AA, were chosen.*

Basic research to determine the effect on the different processes of the coherence of the ambient noise field has not yet been completed. However, plans for this task are currently being formulated and results of this study will be discussed in CPO Quarterly Report No. 6.

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*Texas Instruments Incorporated, 1965: Array Research Semiannual Tech. Rpt. No. 4, Contract AF 33(657)-12747, 15 Dec., p. VIII-2.

3. Processor Design and Construction

During this quarter, work has progressed satisfactorily on the design and construction of the auxiliary processor. On 30 September, the MCF, which is the prime unit, was taken off-line at CPO, acceptance-tested as a precautionary measure*, and packed for shipment to the Apparatus division of Texas Instruments. The unit was shipped on 1 October and arrived in Dallas on 3 October.

As of 31 October, the end of reporting period, the following milestones had been reached on the construction of the processor:

- The DMCF had been modified to interface with the auxiliary processor and had been run through the formal acceptance test to show that it would still function as a single-unit multichannel filter system.
- Construction of the auxiliary processor and check-out of the processor had both been completed. Results showed that the hardware was in working condition and would function as expected as a single piece of equipment.
- The two processors had been interconnected and overall system checkout had begun.
- The engineering portion of the handbook was 95-percent complete
- The final copy of the acceptance test was 90-percent complete.

Also, the complete program is on schedule and is expected to meet the following deadlines:

- 1 December 1966 — Complete checkout
- 15 December 1966 — Complete acceptance tests
- 16 December 1966 — Begin preparations for shipment to CPO
- 1 January 1967 — Complete installation of the two units at CPO

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* Texas Instruments Incorporated, 1966: CPO Special Rpt.No. 2, Contract AF 33(657)-14648, 21 Sept., Appendix B.

D. MCF EVALUATION

1. Introduction

This study is directed toward determining the increased detection capability provided CPO by the MCF and is oriented toward analyst interpretation. Significant evaluation of this increase is based upon the development for each month of two lists of events — one containing events detected on the MCF outputs and the other containing events detected without the aid of the MCF. Results for the month of July 1966 were reported in CPO Quarterly Report No. 4* and showed an increase of 195 events or 63.725 percent with the processor.

2. Presentation of Data

During the reported period, compilation of the two lists of events for August 1966 data was accomplished. The complete lists are shown in Appendix B. Results of this study are summarized in Table 3, which shows the daily total for both lists and the daily percentage increase in the number of events reported using the MCF. From the table, the following summary comments are made:

- Processor results showed an increase of 165 events (46 percent).
- On 9 August, the percent increase was -7 when 14 events were reported without the processor and only 13 events were reported with the processor. This relatively small number of events reported with the processor, as compared to the data without the processor, is due to the fact that the processor was off-line for several hours during the day because of an electrical storm at the station. (See subsection IIC-3 for a discussion of processor downtimes and coefficient losses.)

To point out the type of events which station personnel detected only on the MCF output, Figures III-8 through III-13 are presented. These figures demonstrate the advantage given the station personnel by the MCF outputs compared to normal station data. Station time of the P-arrivals is shown by the small arrow. The first motions of the P-arrivals on the DMCF output, which is delayed by 0.85 sec**, is shown by the large arrows.

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*Texas Instruments Incorporated, 1966: CPO Quarterly Rpt. No. 4, Contract AF 33(657)-14648, 28 Oct.

*This delay is due to the two-sided filters used in the processor. The processor delay time is shown by the second break in the last trace on the secondary records. The station time, as shown by the first break in the same trace, lines up with the time marks displayed across the record.

Table 3

CPO MCF OUTPUT STUDY FOR AUGUST 1966

Date	Number of Events Reported Without MCF Data	Number of Events Reported With MCF Data	Percent Increase in Number of Reported Events With MCF
01	15	21	40
02	7	13	86
03	8	14	75
04	10	23	130
05	No Data Available	22	
06	11	22	100
07	13	17	31
08	11	19	73
09	14	13	-7
10	15	16	7
11	12	20	67
12	9	14	56
13	8	16	100
14	10	11	10
15	13	23	77
16	17	18	6
17	17	22	29
18	19	23	21
19	No Data Available	24	
20	23	28	22
21	13	17	31
22	13	24	85
23	11	14	27
24	11	17	54
25	5	9	80
26	11	19	73
27	10	15	50
28	16	25	56
29	11	19	72
30	12	14	17
31	13	17	31
TOTAL	358	523*	46

*Total does not include result for days when no data available for column without MCF data

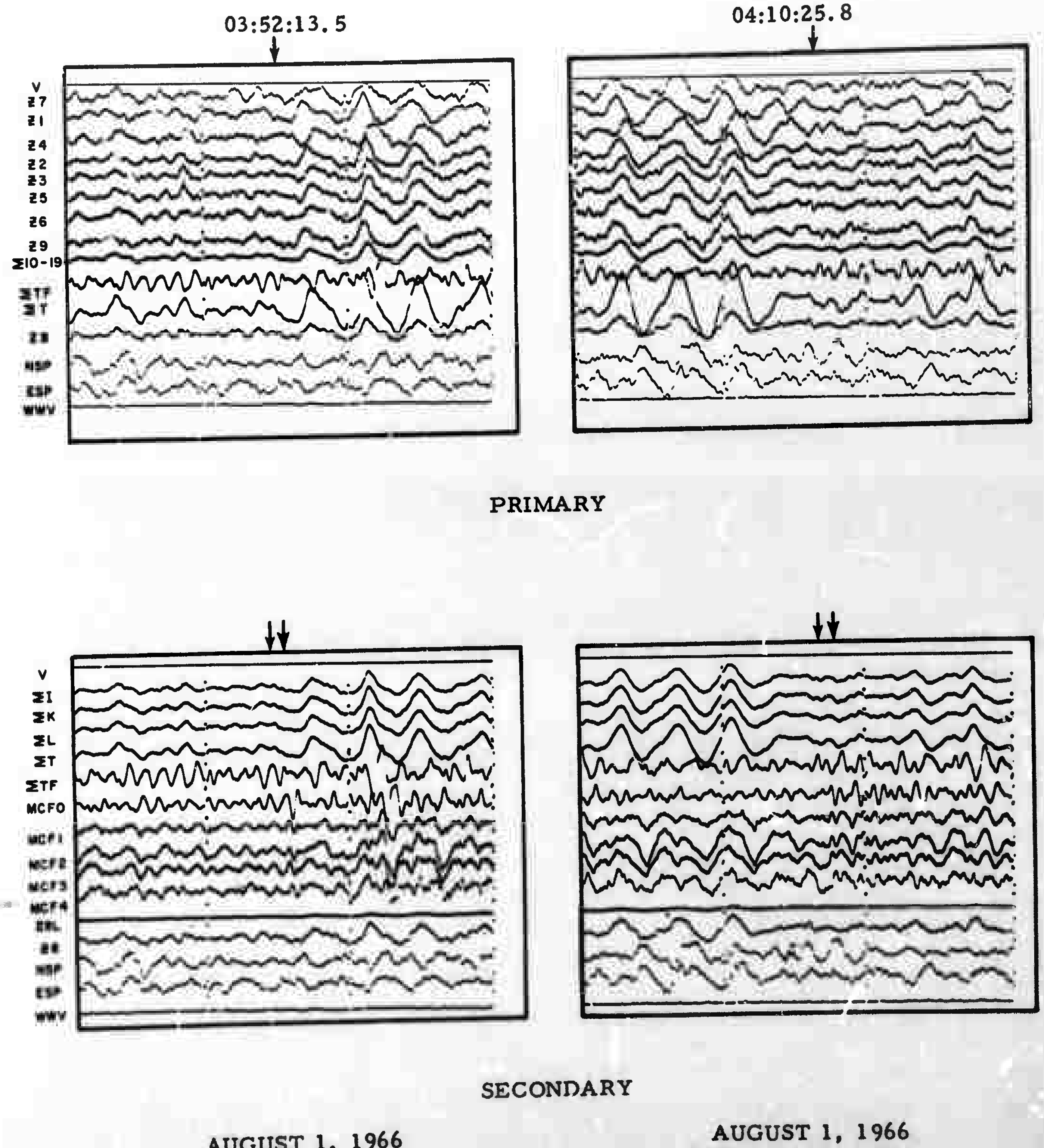


Figure III-8. CPO Primary and Secondary Develocorder Records

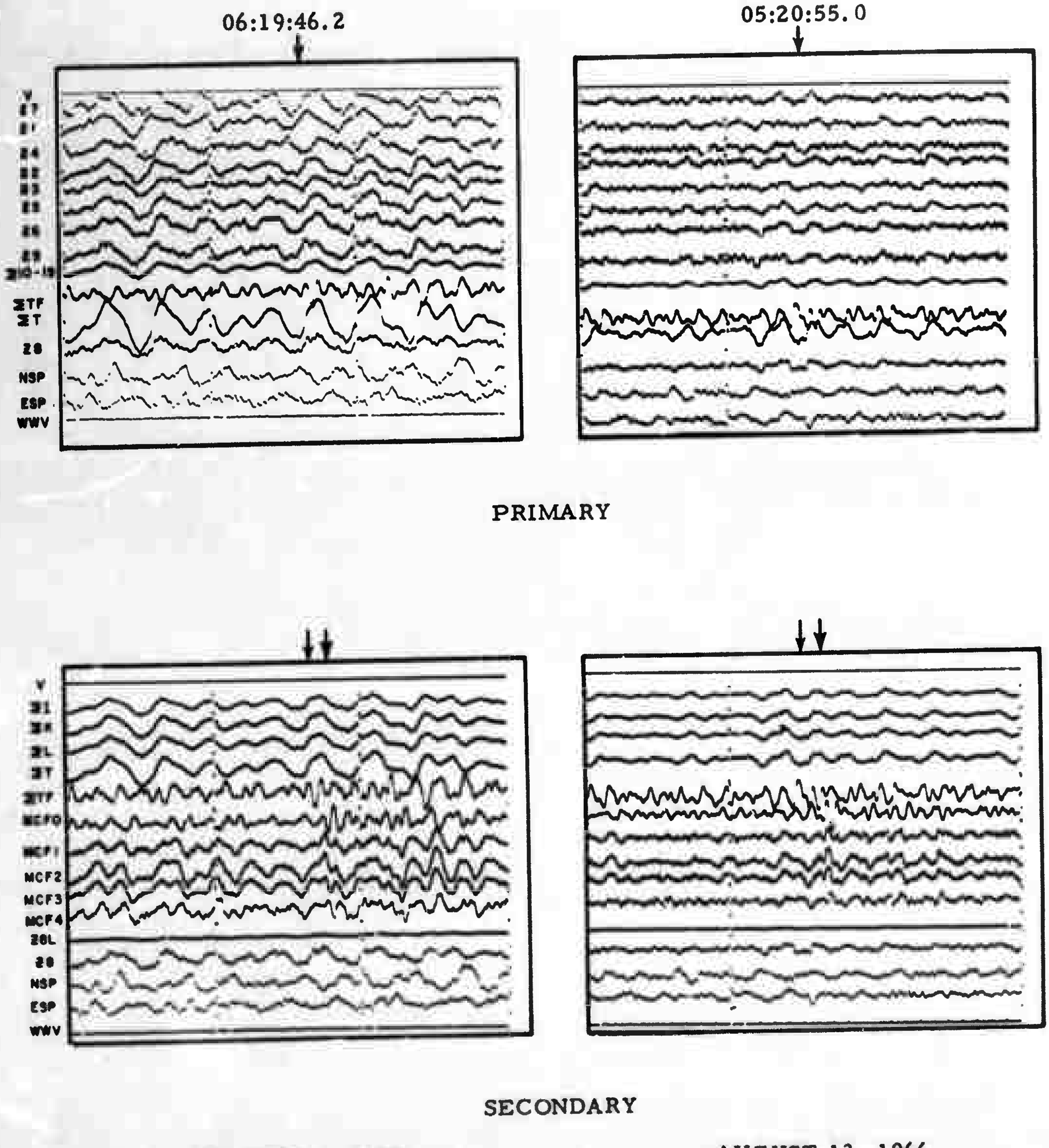


Figure III-9. CPO Primary and Secondary Develocorder Records

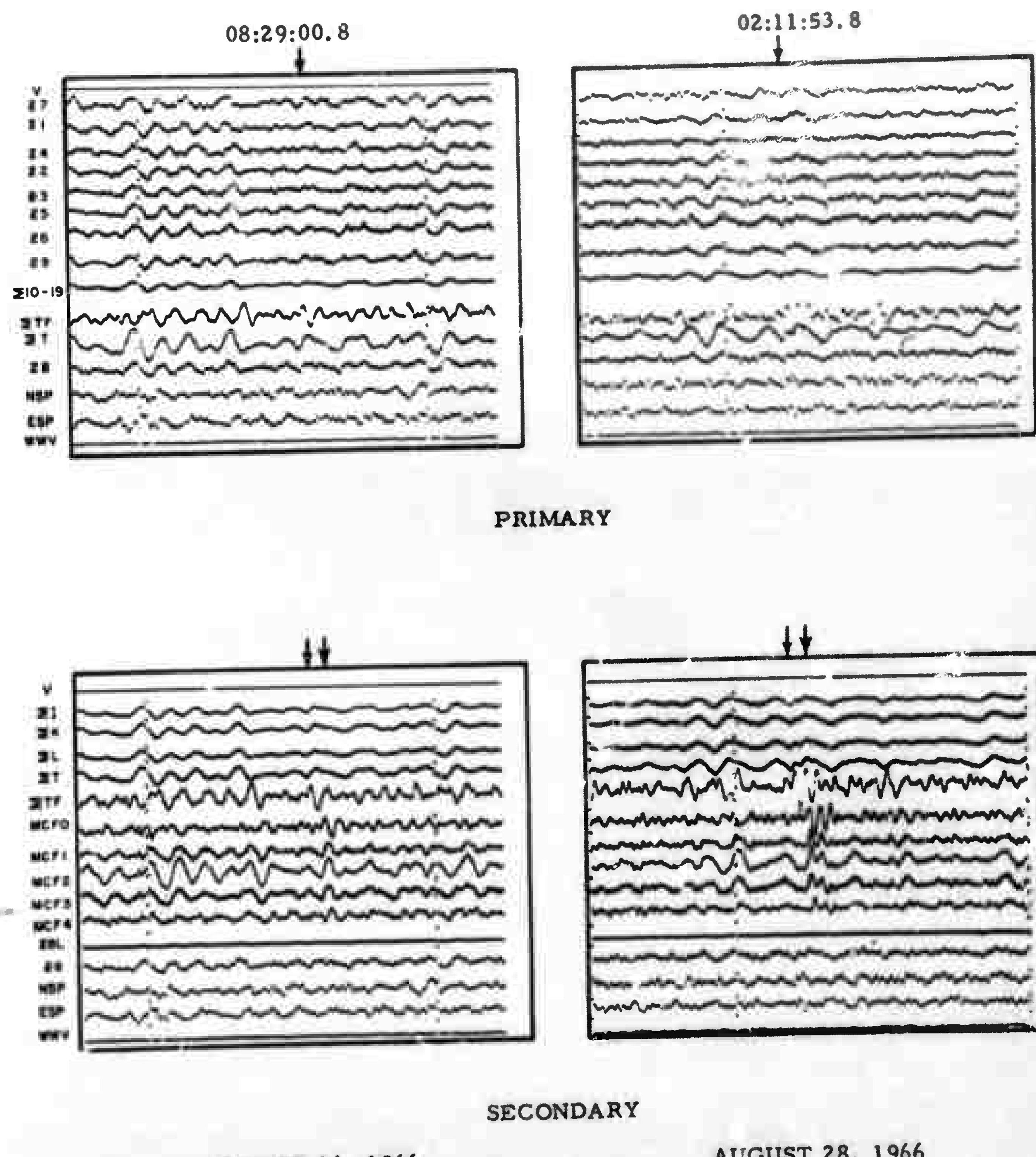


Figure III-12. CPO Primary and Secondary Develocorder Records

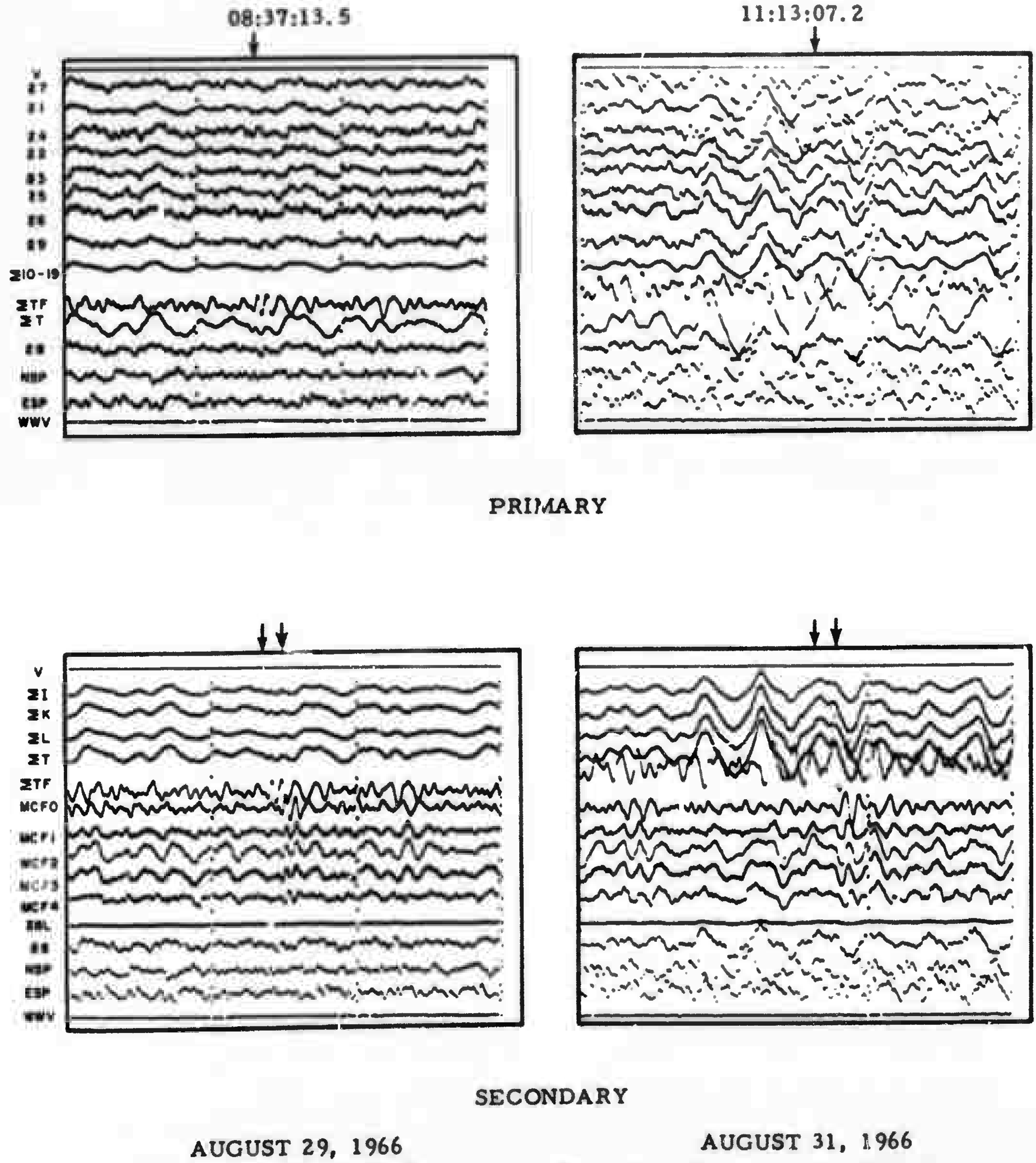


Figure III-13. CPO Primary and Secondary Develocorder Records

3. Conclusions

The results mentioned in the preceding and presented in Table 3 show that there is an advantage given to station personnel through use of the processor outputs. Future plans for this study call for compiling similar lists each month when the processor is available on-line at CPO. Also, as a result of this study, other items will be investigated and evaluated including:

- The possibility of revising standard station analysis procedures to better utilize the MCF
- Determination of false alarm rates for the two lists of events
- A determination of why the number of reported events did not decrease during October 1966 as compared with previous months when MCF was operating on-line at CPO.

E. IMPROVEMENT OF VISUAL DATA DISPLAY

The purpose of this task is to improve visual Develocorder data displays in order to aid station analysts in interpretation of event arrivals. At present, two approaches to this task are being studied; the first of these is the development of single-channel filters which will be applied on-line in the MCF to remove system amplitude and velocity responses. The second effort is a study of several variable display techniques. Included will be both variable area playbacks and bandpass filtering of recorded events to determine which type of system is best.

1. Single-Channel Filtering Technique

In this task, the visual data display is improved by removing the system amplitude and velocity responses using single-channel filters which will be applied on-line at CPO using the MCF. Removal will be accomplished over various frequency bands. The rejection of the predominant 4 to 6 second-period microseismic energy will be particularly necessary.

To accomplish this task, station personnel calibrated the Z1 to Z10 seismometers twice daily for 1-1/2 months at the frequencies of 0.25, 0.50, 0.75, 1.00, 1.50, 2.00, and 3.00 cps. From these calibrations, an average response for each of the seismometers was then calculated to account for the daily variations in the responses. Since only the responses for Z1 to Z10 were available, these 10 responses were averaged to yield one response which should be representative of all 19 short-period instruments. A comparison of this average measured response is shown in Figure III-14 and is compared with the vendor's published response.

From the amplitude response, a system velocity response was obtained by scaling the amplitude response by the factor $2\pi f$, where

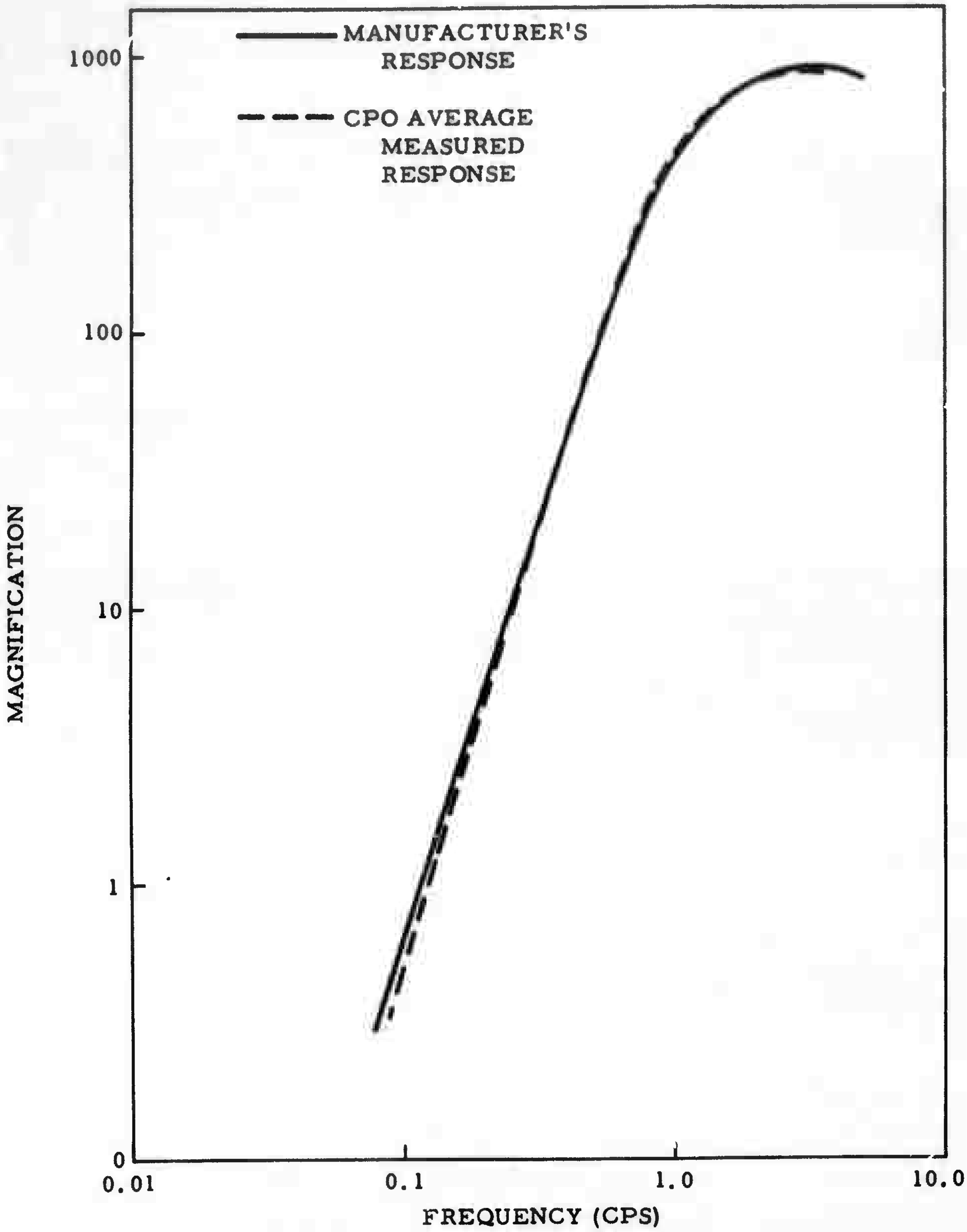


Figure III-14. Comparison of JM SP Responses

f is the frequency. To obtain the response of the filters which would remove the amplitude and velocity responses, reciprocals of these responses were calculated and are displayed in Figure III-15.

As of 31 October, several unsuccessful attempts had been made to design the two single-channel filters. A weighted mean-square-error technique was used which weights the importance of duplicating the desired response shape over specified frequency bands. This technique, although effective in providing an optimum filter response, does require some experimentation with weighting factors to determine a suitable combination.

It is planned to complete the development of these filters with a specified passband of 0.3 to 3.0 cps, and then evaluate the improvement to visual analysis of CPO data using filtered signal and noise data. Results of the evaluation would suggest variations to this approach which should be tried.

2. Variable Display Technique

Several different playback techniques have been analyzed in conjunction with improving visual display of data to determine which technique or combination of techniques is best to aid station analysts in picking event arrival times and event first-motion directions and identifying event phases.

Early results in this task have shown that a good aid technique in the identification of first arrivals and phase detection is a combination of variable area playbacks with wiggly traces and bandpass filtering (0.8 to 1.8 cps). Figure III-16 shows a small earthquake recorded at CPO on 9 May 1963 from the Pacific Ocean at an approximate distance of 40 degrees. "A" shows the event as recorded at CPO, "B" shows the variable area wiggly trace playback of the event and "C" shows the same data as "B", except the event has been filtered by a bandpass filter with a 0.8 to 1.8 cps passband.

This figure clearly shows the advantage of this method in the analysis and reporting of small earthquakes. Number 1 shows the first arrivals of the event, while 2, 3 and 4 point out later phases of the event. Of special interest in this figure is the way that phase 4 stands out from the background in parts "B" and "C" as compared to part "A", where it would probably not be identified.

Further analysis of other events is to be performed during the next quarter and will be discussed in a special report. Also, other similar techniques will be investigated.

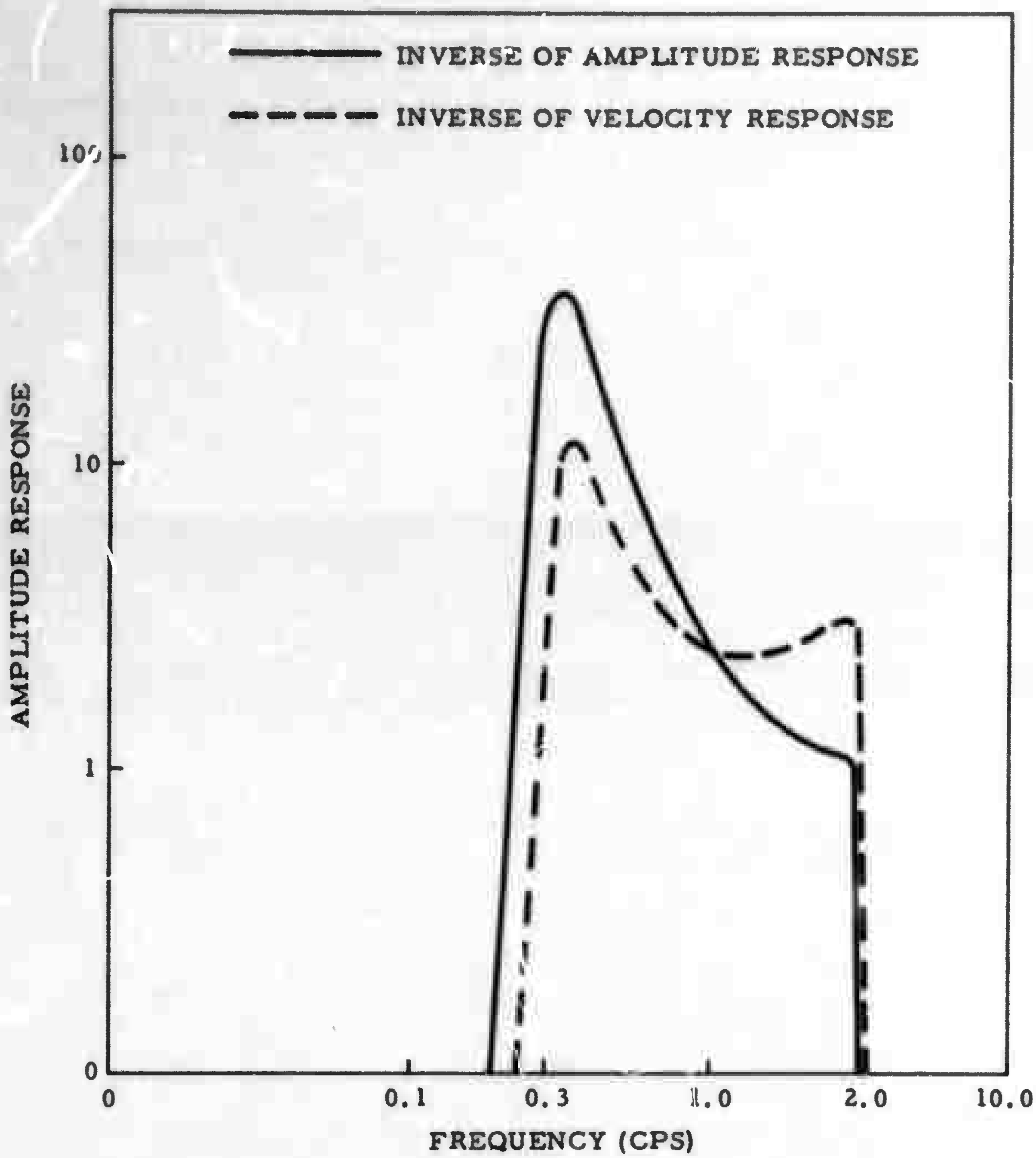
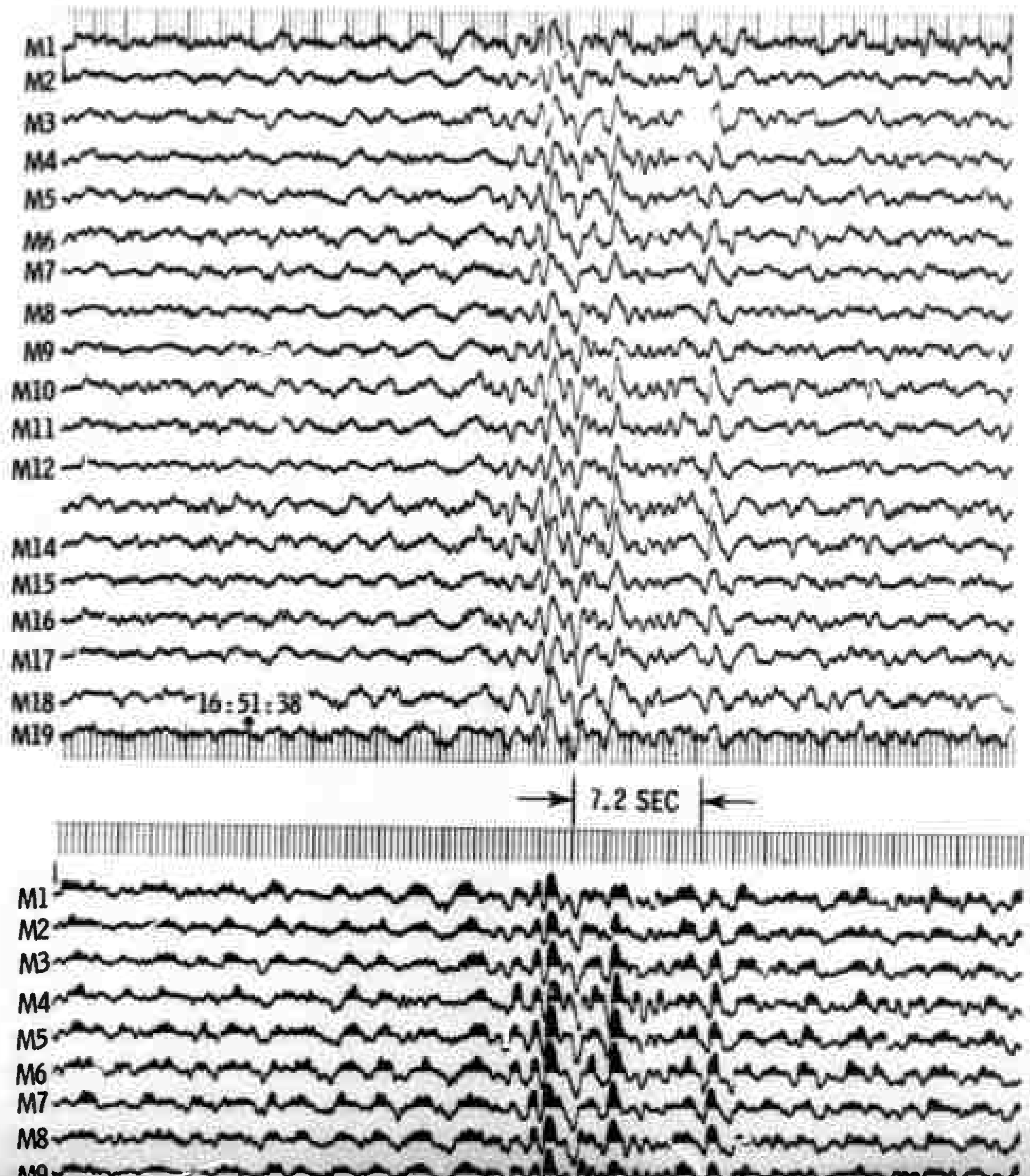
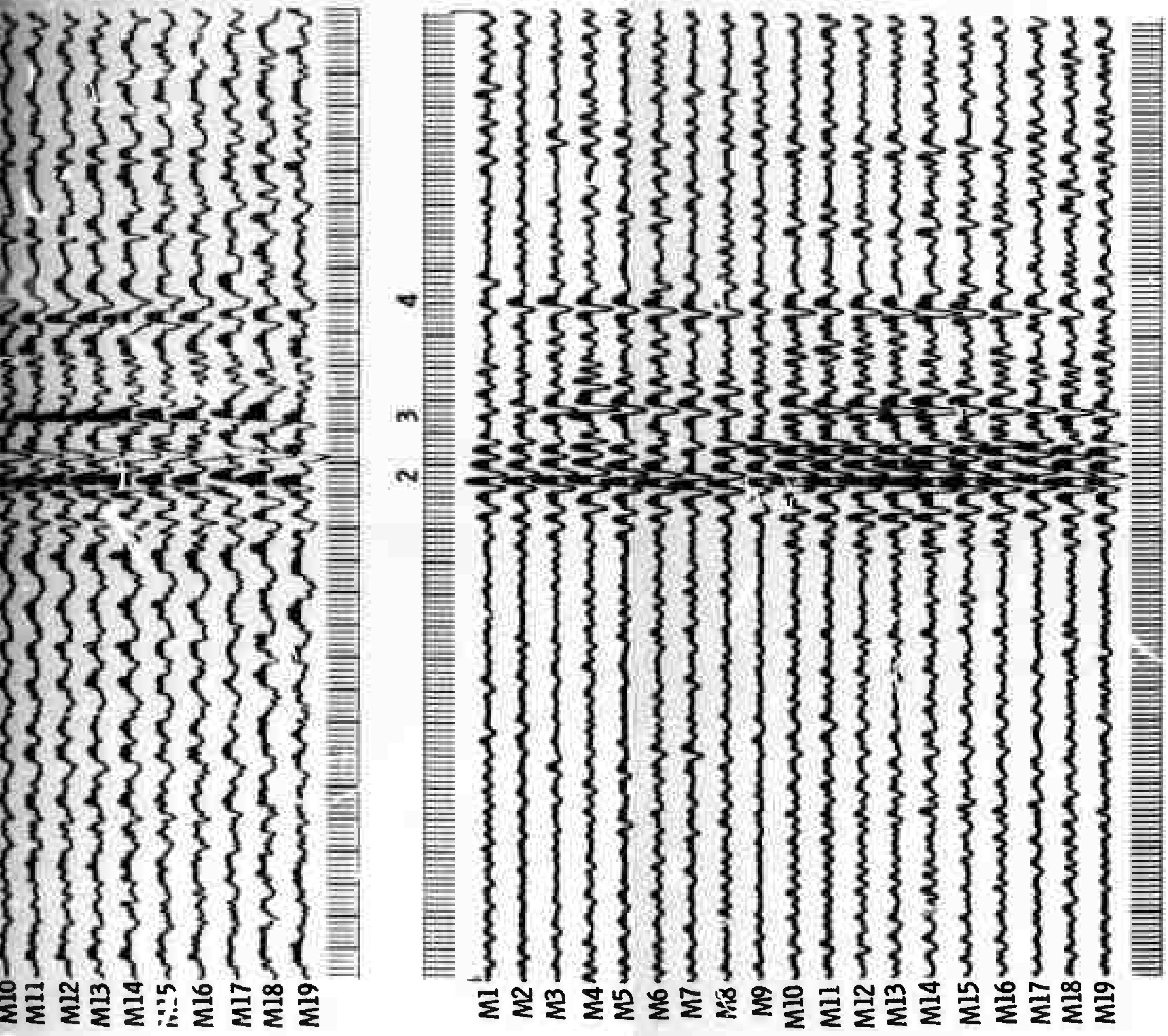


Figure III-15. Inverse of Amplitude and Velocity Response over Desired Passband

A

A


M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
M14
M15
M16
M17
M18
M19
16:51:38
7.2 SEC
M1
M2
M3
M4
M5
M6
M7
M8
M9



C

Figure III-16. CPO Event 9, May 1963: (A) Straight Playback; (B) Variable Area, Wiggly Trace; (C) Variable Area, Wiggly Trace, Passband Filtered 0.8 → 1.8 cps

APPENDIX A

COEFFICIENT LOSS PROBLEM

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APPENDIX A

COEFFICIENT LOSS PROBLEM

Presented in this appendix are the details of the coefficient loss problem which have been experienced at CPO with the MCF since installation. As discussed in Section IIC-3, a probable cause of this loss problem has been identified and a suitable modification incorporated into the MCF to avoid further losses.

A. PROBLEM HISTORY

Available data concerning coefficient losses which has been routinely collected in the observatory MCF operation and maintenance log is outlined in Table A-1. Analysis of this data yields the following conclusions:

- Coefficient losses are associated with local electrical storms
- The losses occur randomly among input channels, output channels and filter points
- Coefficient losses are characterized by failure to complete a read/write cycle for the coefficient

The initial processor problems were characterized not only by coefficient losses, but also by entire memory losses (i.e., the entire memory would contain zero coefficients). During May the memory loss problem was corrected and the processor restored to good operating condition which at that time was thought sufficient to correct the coefficient loss problem. The following excerpts from a standard TI maintenance report describe the problems encountered up to May and the corrective action taken at that time:

"Memory losses were caused by two problems. One was several damaged components in both the memory subsystem and in the processor logic power supply, and the other problem was some bad solder joints on a printed circuit card in the memory. The directness in locating these problems was hampered because memory loss did not always occur for the same set of applied conditions and because of a few peripheral problems which clouded the analysis.

"The bad components were mostly located in power supply sections of the equipment. Rectifier CR8 in the memory power supply was knocked out at 18:04 GMT on 8 April, and diodes CR1 and CR2 and transistor

Table A-1

COEFFICIENT LOSS DATA

Date	Time	Location: Output Chan	Location: Input Chan	Location: Filter Point	Coeff After Loss	Conditions
4-8-66	2342	2	19	25	0000	Lightning
		3	12	24	0000	
4-12-66	Overnight	0	12	00	0000	Lightning
		0	12	01	0000	
		0	12	02	0000	
		0	13	04	0000	
		0	13	05	0000	
		0	13	06	0000	
		0	13	07	0000	
		0	13	09	0000	
		1	11	02	0000	
		1	11	06	0400	
		1	11	08	0000	
		1	11	10	0000	
		2	10	00	0000	
		2	10	01	0000	
		2	10	02	0000	
		2	10	03	0000	
		2	10	04	0000	
		2	10	05	0000	
		2	10	06	0000	
		2	10	07	0000	
		2	10	09	3413	
		3	16	70	0000	
		3	16	71	0000	
		3	16	72	0000	
		3	16	73	0000	

Table A-1 (Contd)

Date	Time	Location Output Chan	Location Input Chan	Location Filter Point	Coeff After Loss	Conditions
		3	16	74	0000	
		3	16	75	0000	
		3	16	76	0000	
		3	16	77	0000	
		3	16	78	0000	
		4	13	00	0000	
		4	13	01	0000	
		4	13	02	0000	
		4	13	03	0000	
		4	13	04	0000	
		4	13	05	0000	
		4	13	06	0000	
		4	13	07	0000	
		4	13	08	0000	
		4	13	09	0000	
4-14-66	1621	0	13	78	0000	Power Failure
4-14-66	2315	0	16	00	0000	
		0	16	66	0000	
		0	16	68	0000	
4-16-66	2202	1	04	16	0000	
4-18-66	Overnight	0	U	U	U	U
		1	U	U	U	
		2	U	U	U	
		3	U	U	U	
4-26-66	1452	U	U	U	U	U
4-27-66	2007	U	U	U	U	U
5-22-66	1518	0	U	U	U	Lightning
		3	U	U	U	

Table A-1 (Contd)

Date	Time	Location: Output Chan	Location: Input Chan	Location: Filter Point	Coeff After Loss	Conditions
		4	U	U	U	
5-26-66	1600	0	16	78	L	Lightning
		1	16	05	L	
5-27-66	1448	0	18	78	L	Lightning
6-17-66	1459	1	05	19	0000	Lightning
6-30-66	2211	0	01	05	L	Lightning
		0	02	15	L	
		1	04	36	L	
		1	10	33	L	
7-1-66	1500	1	05	27	L	Lightning
7-2-66	2306	0	13	28	L	Lightning
		1	06	12	L	
7-3-66	Overnight	3	01	33	L	Lightning
7-6-66	0244	0	08	33	L	Lightning
7-7-66	1448	0	01	13	0000	Lightning
		0	11	13	0000	
		0	14	24	0000	
		1	05	20	0000	
		2	03	20	0000	
		2	16	09	G	
		4	03	21	G	
7-16-66	2014	[illegible]	01	08	G	Lightning
		0	00	08	L	
		0	13	38	L	
		0	18	78	L	
		1	00	08	L	
		2	16	27	L	
		2	18	07	L	
		2	18	14	L	

Table A-1 (Contd)

Date	Time	Location: Output Chan	Location: Input Chan	Location: Filter Point	Coeff After Loss	Conditions
8-3-66	2009	0	00	00	L	Lightning
		3	06	52	0000	
		3	06	59	0000	
		3	11	67	0000	
		3	13	69	0000	
		1	07	17	0000	
8-9-66	2054	0	06	15	0000	Lightning
		0	07	06	0000	
		0	10	27	0000	
		0	10	54	0000	
		0	11	73	0000	
		0	17	18	0000	
		1	07	09	0000	
		1	18	26	0000	
		2	00	15	0000	
		2	17	18	G	
		4	00	14	L	
		4	02	37	0000	
		4	05	18	0000	
8-12-66	1600	0	00	00	0000	Lightning
		0	07	23	L	
		0	13	18	0000	
		0	13	19	G	
		1	13	18	0000	
		3	07	23	0000	
8-14-66	2303	0	08	30	0000	Lightning
		2	08	28	0000	

Table A-1 (Contd)

Date	Time	Location: Output Chan	Location: Input Chan	Location: Filter Point	Coeff After Loss	Conditions
		3	08	27	0000	
8-17-66	1606	0	00	00	0000	Lightning
		0	08	35	0000	
		0	18	35	0000	
		1	06	25	0000	
		2	07	34	0000	
		2	17	05	L	
8-20-66	2143	0	00	00	0000	Lightning
		0	00	26	0000	
		0	02	57	0000	
		1	10	29	0000	
		1	11	60	G	
		2	00	00	L	
		2	04	32	0000	
		2	07	33	0000	
		2	10	29	G	
		3	12	17	0000	
		4	00	00	G	
8-29-66	2300	1	11	06	G	
		0	18	78	0000	U
9-14-66	2204	0	10	45	0000	U
9-19-66	1556	0	00	00	0000	Lightning
		0	00	02	0000	
		0	00	04	0000	
		0	05	06	0000	
		0	07	05	0000	
		0	18	78	0000	
		1	00	00	0000	
		[illegible]	00	01	0000	

Table A-1 (Contd)

Date	Time	Location Output Chan	Location Input Chan	Filter Point	Coeff After Loss	Conditions
		2	00	00	0000	
		2	04	33	0000	
		3	00	09	0000	
		4	00	00	0000	
		4	00	10	0000	

U - Unknown
L - Lost Bit
G - Gained Bit

Q1 on the data-saver card and transistor Q3 of board B24 and Q1 of board B26 were found to be bad after the processor stopped working at 00:58 GMT on 29 April. The station log shows thunderstorms with lightning in the area on both of these occasions. Station personnel replaced these components, but random memory losses still occurred and assistance was requested.

The remainder of the problem was traced to two damaged 8000 μf electrolytic filter capacitors in the processor logic power supply and seven bad solder joints on board B22 in the memory. One of the capacitors had its vent blown open, and indications are that they were damaged at the same time as the previously noted components. They are located ahead of the regulators in the Dressen-Barnes 50 amp 4 v supply. The regulators were able to supply a smooth output despite the reduced effectiveness of the filter capacitors. Memory losses occurred from this problem because the reduced stored energy in the capacitors of this supply at power turn-off or failure allowed the 25 amp load on this supply to drain it to a low voltage before the data-saver circuit in the memory reacted. Thus, inadequate commands were sometimes received by the memory before the data-save cycle and memory information were destroyed. No replacement capacitors were available at the site nor in Nashville so a special fix circuit was devised in the interim. Dressen-Barnes, Inc., the supply manufacturer, was contacted, and replacement capacitors were to be sent directly to CPO under the supply's 1-yr parts warranty. The fix circuit was a one transistor amplifier which detects an abnormally low voltage drop across the supply's series regulator transistors and initiates a stop state in the processor. Normal automatic clear-start occurs on power restoration if the "autostart" button is set. The circuit, although intended as temporary, could act as a redundant data saver when the capacitors are replaced in the logic power supply. If it is left in, improvements could probably be made in its operation by a more thorough design.

"The bad solder joints were the cause of the system losing coefficients under quiescent operating conditions. Seven joints on board B22, although appearing good even under moderate magnification, allowed the pin to move up and down through the solder pool when the board was flexed. The cause of the poor joints was apparently inadequate tinning of the leads on relatively heavy potted delay line modules prior to the flow soldering process. The joints were good but possibly weak when the unit was in Dallas and probably failed during transport of the system over the rough roads to the site. Fabritek certifies their units to a "standard commercial" 10 g vibration and a 15 g shock specification. Resoldering these seven joints cured the quiescent operating core loss occurrences.

"The other lesser things which masked the above problems and lengthened the troubleshooting time included occassional electrical noise generated by the line-printer ink-ribbon reversing mechanism, an intermittent ground connection in the molded power cord of the paper tape spooler, low contact pressure on one Elco connector in the memory, and noise generated by the memory power switch when it was used to test the data saver. The printer-ribbon-reverse noise caused an occassional print action in the printer during the long printer-enabled conditions imposed by troubleshooting. The noise was reduced by inserting capacitors across the magnetic clutch coils inside the printer. The intermittent power cord ground created transient noise in the paper tape reader logic due to a power-line filter circuit which utilizes that ground line. A replacement cord was installed. Increasing the contact pressure on the one Elco connector permitted the memory to tolerate quite severe card rattling without malfunction. Rattling of cards in the processor was likewise tried without upsetting system operation. The power switch on the memory power supply occassionally created noise on turn off-on, probably due to contact bounce. Usually 20-30 off-on cycles in a test period were required to get a malfunction during memory self-test. Decoupling capacitors were placed both across the switch and the power transformer primary to reduce the noise when it occurred. This upped the test cycles required to cause a loss in self test to 50 to 80 as indicated by about six tests of that many cycles each. It should be noted that this is not a switch used during normal system operation and is covered by an access panel. After the two main problems were corrected, the entire system was tested twice with over 100 power on-off cycles initiated with either the main system switch or external power interruption without a memory loss.

"Additionally, Fabritek readjusted the schmoo pattern on the memory as a normal requirement after the unit has been in operation after the initial several hundred hours. Two transistors were also replaced on inhibit driver cards which had degraded somewhat and reduced the memory drive margins from ±10 percent to ±5 percent. This degradation was apparently random component aging but did not affect the system operation. Procedures are given in the handbook to locate such gradual reductions of system operating margins and may be used as a form of preventive maintenance, if desired. Fabritek also replaced the data saver board in the memory because some etch was lifted in the replacement of components damaged on 29 April by use of too large a soldering iron.

"In summary, the system was repaired, and the major problems since installation can be attributed to several damaged components and some weak solder joints in the memory. The damaged components were mostly located in power supply sections and were likely damaged by an over-voltage condition in excess of suppression capability of the input line filter and line regulator, such as lightning could cause. Lightning arresters are installed on the power pole transformer primary."

After this maintenance and investigative effort in May, and after observing the system for one month, it was evident that the memory loss problem no longer existed but coefficient losses still occurred. Station procedures were then adopted to collect data on the loss problem and to attempt to isolate the phenomena responsible for the losses. These procedures were

- Run an hourly all-channel step-test while the station is manned
- Display the input power variations on the fourth Develocorder
- Cause the MCF to compute an all-channel step-test whenever it cycled through "stop"
- Time permitting, spot check internal voltages on a rotating-continuous schedule for unusual conditions
- Conduct additional pertinent testing as necessary

Little additional information had been gained in July other than that there was a definite correlation of loss with local electrical storms. It was hypothesized that short-duration transients during these storms could be propagating through portions of the station and causing losses through an electrical ground loop. To avoid this possibility, the following electrical ground changes were made:

- The MCF input power source was changed to run off the instrumentation source so that the PTA's, Develocorders and FM tape systems, (which have direct electrical connection with the MCF) shared a common MCF ground. Because of available station power circuitry, the MCF originally used the utilities system for input power (i.e., secondary line supplying the observatory lighting, heating, cooling, etc.).
- The electrical grounding system internal to the MCF was modified so that all subsystems utilized a common external ground

After correcting for known ground loop problems which could exist, the sporadic coefficient loss still occurred and was associated with local lightning. The station engineering personnel then attempted to create coefficient losses under controlled conditions by creating phenomena which might occur during electrical storms. The attempt had only limited success, primarily due to unavailability of special test and experimental equipment. However, it was encouraging enough to warrant more sophisticated experimentation oriented to this approach.

Dallas engineers visited CPO again in September to accomplish additional testing and investigate lightning effects. During this effort, it was discovered that coefficient losses could be consistently reproduced by causing short duration 5-msec interruptions in the MCF input power.

The interruptions were created by passing the input current through a relay in which the poles were wired together and then triggering the relay. The interruption was caused by contact bounce. Using this technique, the rate of loss was 50 percent.

Although the cause of loss was not fully understood at the time, it was believed that if the unit could be corrected to withstand these interruptions, the loss problem would be solved. It was decided to bring the MCF back to Dallas on schedule for auxiliary processor interfacing and to further investigate the available facts. This decision was related to the project officer who approved. The decision was based on:

- The wide variety of engineering talent and special test equipment available in Dallas
- The fact that coefficient losses could be reproduced under laboratory conditions

After thorough laboratory testing in Dallas, the problem cause was definitely determined and is discussed in the next subsection along with the present solution.

B. PROBLEM SOLUTION

A circuit has been added to the +4 v, 50 amp Dressen-Barnes logic power supply of the MCF which allows the processor to survive transients of a type which has been found to cause memory core losses. This problem is one of short power line transients, too brief to trip the Fabritek memory data-saver but long enough to affect the logic power supply. Such a transient could cause the logic power supply to lose regulation and create logic noise within the MCF processor controllers such that improper commands were given to the memory and data destroyed. The circuit added to the logic supply is a redundant power source monitor to the memory data-saver, either of which will also set the processor to the "stop" control mode in the event of power problems. The logic supply monitor is required to cause a "data save" for those power line disturbances which affect the processor's logic supply without directly affecting the memory subsystem.

1. Results

No coefficient bit loss occurrence has resulted during extensive testing of the circuit and the theory. Approximately 100 transients of the type shown to have at least a prior 50 percent chance of causing a coefficient loss were imposed on the system during the tests. The manner used to effect the data-save is to force the system to a stop mode during the disturbance and for a short time afterwards, this is the same as that used by the integral memory data-saver. The memory data-saver standard delay recommended by Fabritek is about 120 msec. The delay to automatic restart of the processor implemented in the power supply circuit during these tests was about 100 msec after regulation was restored. Power turn-on and turn-off, complete interruption, short power loss transient, and long power loss transient tests were conducted without coefficient loss. Power line overvoltage transient tests were not conducted.

A picture of the breadboard circuit installed in the CPO MCF is shown in Figure A-1, andits operation is shown in Figure A-2. The top trace shows the 115 v-ac regulated power (Sorensen Line Regulator Output) within the system. A transient power loss was created which clipped off the lower portion of the second 115 v-ac cycle shown on the left. Another trace superimposed within the 115 v-ac trace shows the output of the breadboard circuit dropping to a low state. This signal remains low for 100 msec after the unregulated d-c in the logic supply (shown by the bottom trace) has recovered and the supply is no longer in danger of losing regulation. The threat of regulation loss is measured as the d-c level of the unregulated d-c feeding the series regulators in the logic supply. The fourth trace, located in the middle of the picture, is the +4 v regulated voltage. Loss of regulation is shown by that trace during the initial drop in the unregulated voltage following the transient. Regulation was maintained during the recovery undershoot as the regulators settled, but the monitor threshold was apparently again crossed since the signal output remained down 100 msec after that time.

Figure A-3 is the schematic of the breadboard used to verify the theory of the coefficient loss fix. It consists of a Schmitt trigger, one shot, time-delay section, output stage, and temporary energy storage for operation of the circuit during severe transients. The Schmitt trigger monitors the level of the unregulated + 14 v feeding the series regulators. The time-delay section delays the resetting of the stop command for approximately 100 msec after the Schmitt has reset. The one shot ensures that a minimum pulse of about 400 μsec is supplied to the time delay circuit through the "or gate" to adequately set the 100 msec time delay. The output stage buffers the circuit and ensures that the output command does not exceed the regulated output level and couples the command output to such occurrences as output short circuits and firings of the overvoltage SCR devices. It is assumed that the overall circuit could be simplified when more is known about all the problems.

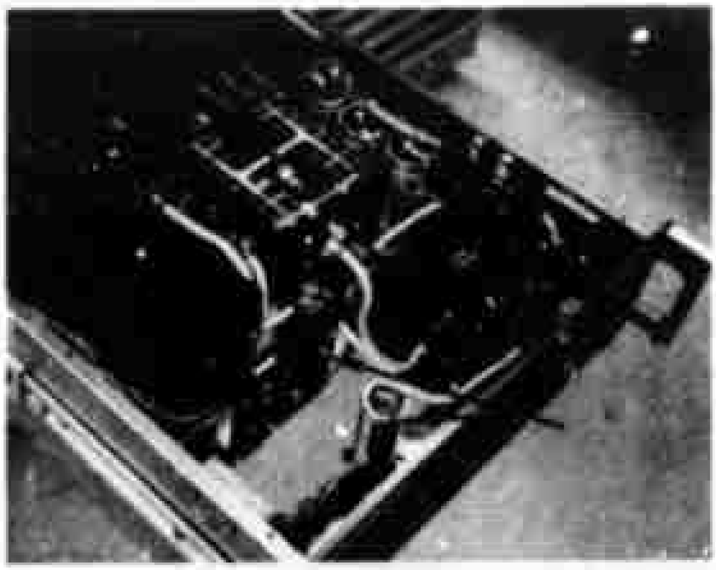


Figure A-1. Logic Power Supply with Breadboard Circuit Installed

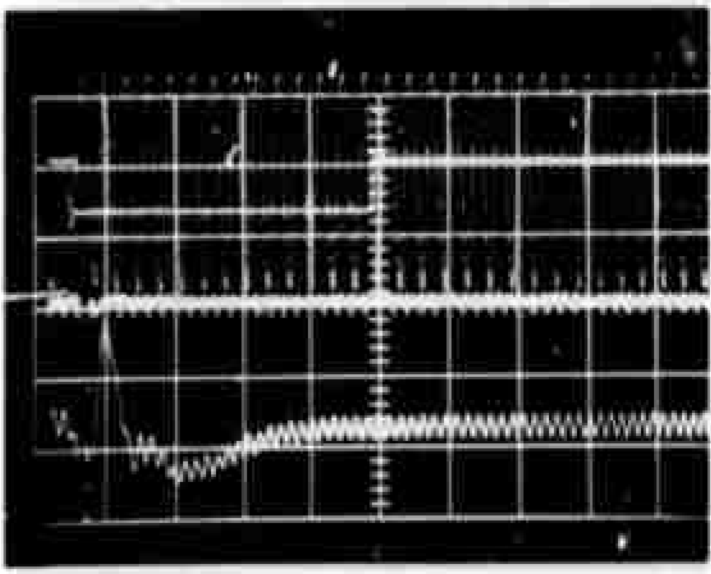


Figure A-2. Operation of the Logic Supply Moniter Circuit Breadboard

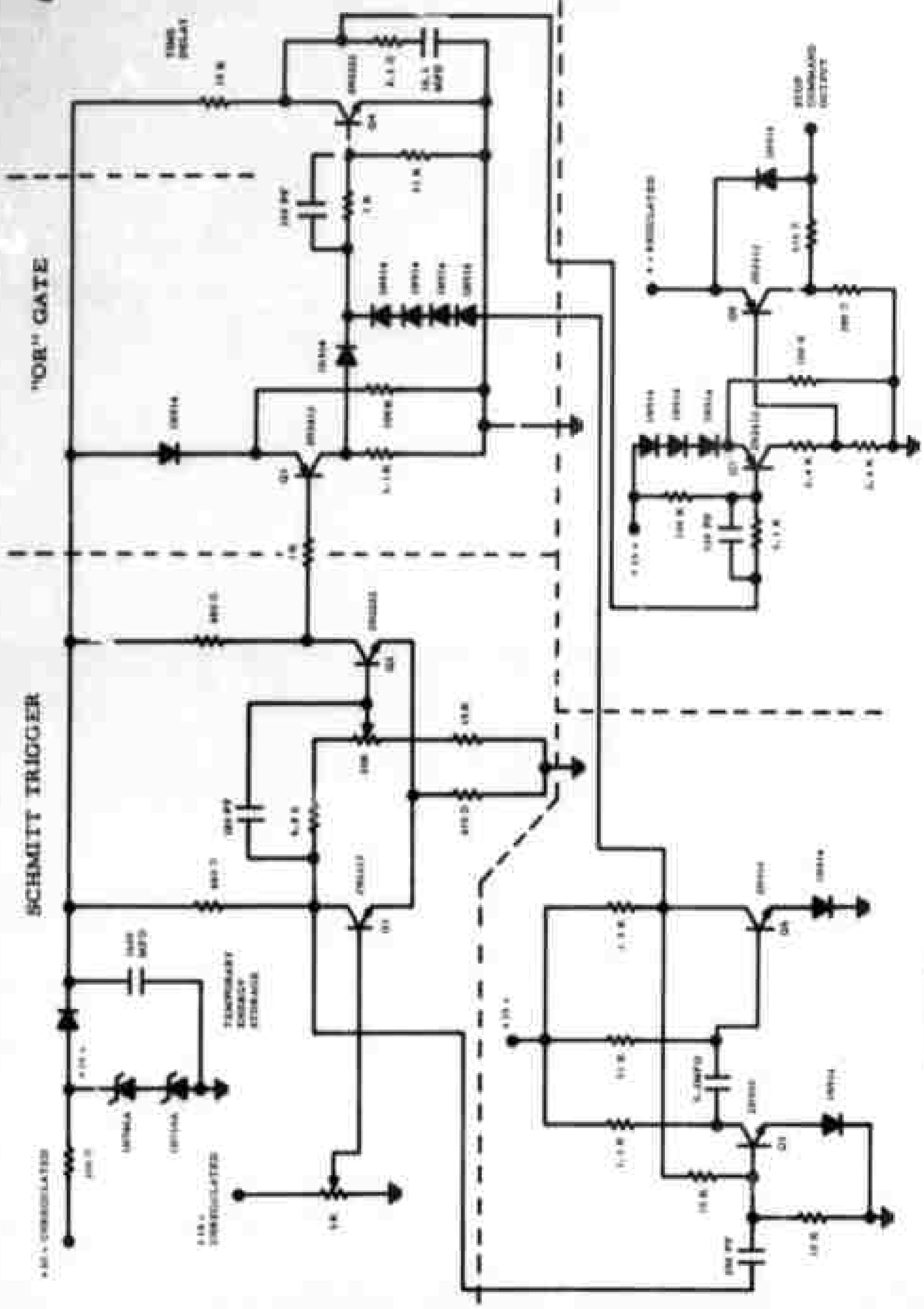


Figure A-3. Breadboard Circuit Design

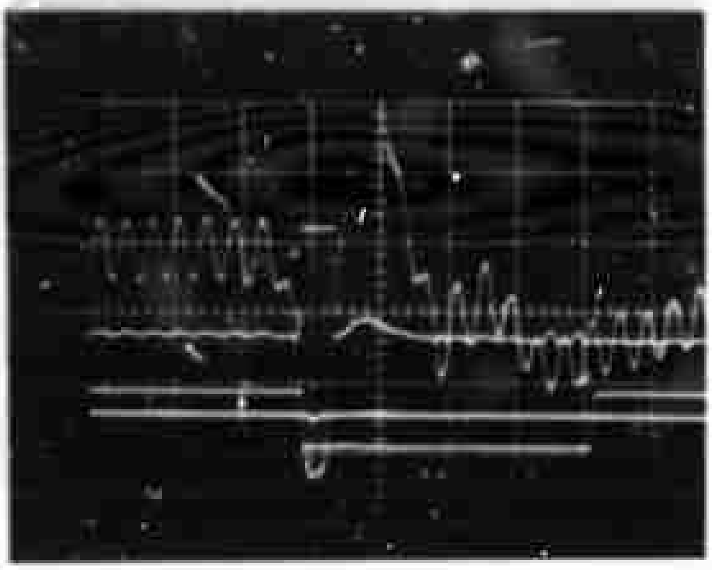
Circuit action to a marginal situation is shown in Figure A-4. The upper trace is the 14-v unregulated power to the series regulator. The energy loss, due to the transient introduced on the power line, is clearly shown. The energy reduction following the transient is from the recovery undershoot of the Sorensen regulator. The second trace shows the Schmitt trigger monitoring the unregulated level. A clean trigger action occurred at the primary transient time and the command, trace 4, is initiated. A very small notch on trace 3, and +4 v regulated transient power voltage, shows the loss of regulation which occurred for the particular transient. Close inspection will show that the stop command was initiated prior to loss of regulation. The processor will react to this command within 5 µsec. This slight disturbance of the +4 v into the logic most likely would not have affected system operation, nor have caused a coefficient loss. The Schmitt trigger is designed to operate in a linear fashion as it approaches the decision points and a second trip is almost initiated by the undershoot energy loss, as can be seen by the small perturbation of the Schmitt trace at that time. Correlation of the Schmitt trace and the unregulated trace at that point is evident, but no loss of regulation occurred since the minimum level for regulation was not reached.

Figure A-5 shows the operation of the power supply monitor circuit and the memory data-saver to a more severe transient. This degree of 4-v disturbance approaches that capable of causing a bad command to the memory resulting in a coefficient loss, but notice that in this case the memory data-saver also tripped. Instances of significant 4-v disturbance without the memory data saver responding appropriately were observed but not often enough to account for the degree of coefficient losses experienced.

2. Conclusions

The breadboard fix installed in the MCF appears to work satisfactorily for the particular disturbance created under laboratory conditions. The full mechanism of the losses is not yet fully understood; however, future planned efforts should provide complete understanding. Plans call for:

- An attempt to simplify the fix circuit; specifically, deletion of delayed start feature will be investigated.
- Placement of the MCF on-line at CPO as soon as possible. The unit will be closely monitored to insure that further coefficient losses do not occur under field conditions.



←+ 14 v Unregulated Voltage 2-v/cm

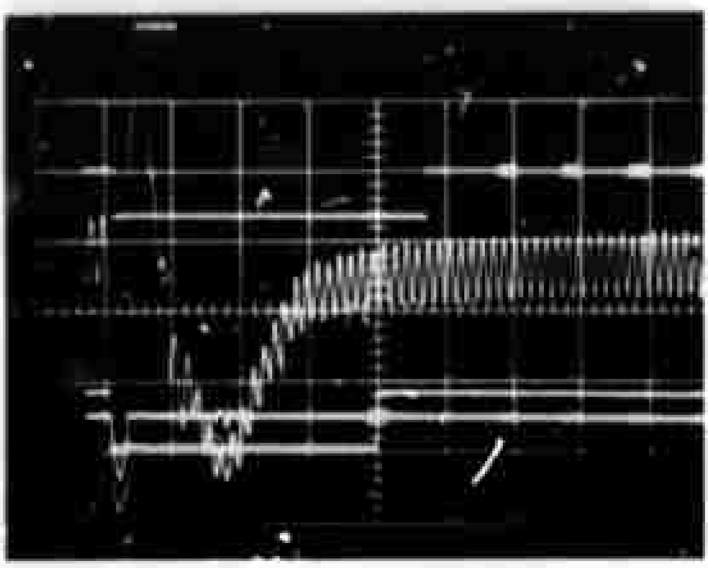
← Schmitt Trigger Monitor 5-v/cm

←+ 4-v Regulated Output 1-v/cm

← Command Output 5-v/cm

Sweep Speed 20 msec/cm

Figure A-4. Operation of the Power Supply Monitor Circuit to Marginal Conditions



← Memory Data Saver, 5 v/cm

←+ 14-v Unregulated Voltage, 2-v/cm

← Power Supply Monitor Output 5-v/cm

←+ 4 v Regulated Output 1-v/cm

Sweep Speed 50 msec

Figure A-5. Operation of the Power Supply Monitor Circuit to Severe Transients

C. LOSS EFFECTS ON OUTPUT DATA

Coefficient losses in the MCF are undesirable and would not occur if the hardware was operating properly. It is believed that the problem is now solved, However, from an operational standpoint, a critical question which should be answered in light of MCF data usability during a loss is: "What effect does a coefficient loss have on visually displayed MCF output data?"

The answer to this question, although straightforward, is difficult to rapidly assess to any degree of accuracy on an individual case basis in the field. A summary answer to this question is

- Theoretically, the output of the affected MCF channel is incorrect if one of more coefficients are destroyed
- The extent of visual data distortion for a single channel under a loss condition may range from none to very severe depending upon the number of input channels affected, the number of coefficients lost per input channel and the value of the individual coefficients lost

As an example of loss effects on visual data, Figures A-6 through A-9 are presented. These figures represent reproduction of actual CPO secondary Develocorder data which contains the MCF outputs for before and after conditions of coefficient loss. In such a comparison, there is no definite means of stating the effect; however, the character of output data can be studied for obvious changes in frequency content or for apparent visually detectable increases or decreases in general trace level. For this approach the assumption must be made that the input character of seismic data is relatable to the output; if a change occurs in the input data over the period being considered, the effect this change has on the output data is known. This is not always the case, (e.g., on high-level noise days when a new organized component may be added to the spatial noise field) but, it is a reasonable assumption.

Analysis of the presented Develocorder records, in conjunction with data presented in Table A-1, indicates the following:

- Figure A-6

  MCF 0 lost one coefficient; MCF 1, one coefficient; and MCF 3, four coefficients. There is no apparent degradation on any of the affected channels

- Figure A-7

  MCF 0 lost six coefficients; MCF 1, two coefficients; MCF 2, two coefficients; MCF 4, three coefficients. Results are inconclusive due to contradiction between apparent affected channels and channels with known losses.

- Figure A-8

  MCF 0 lost four coefficients; MCF 1, one coefficient; MCF 3, one coefficient. No noticable deterioration was present.

- Figure A-9

  MCF 0 lost six coefficients; MCF 1, two coefficients; MCF 2, two coefficients; MCF 4, two coefficients. No apparent deterioration was present after the loss.

In summary, the presented results and past analysis experience at CPO indicate that little noticeble effect occurs in MCF output data during coefficient losses of the type which have normally been encountered since repair of the memory loss problem in May.

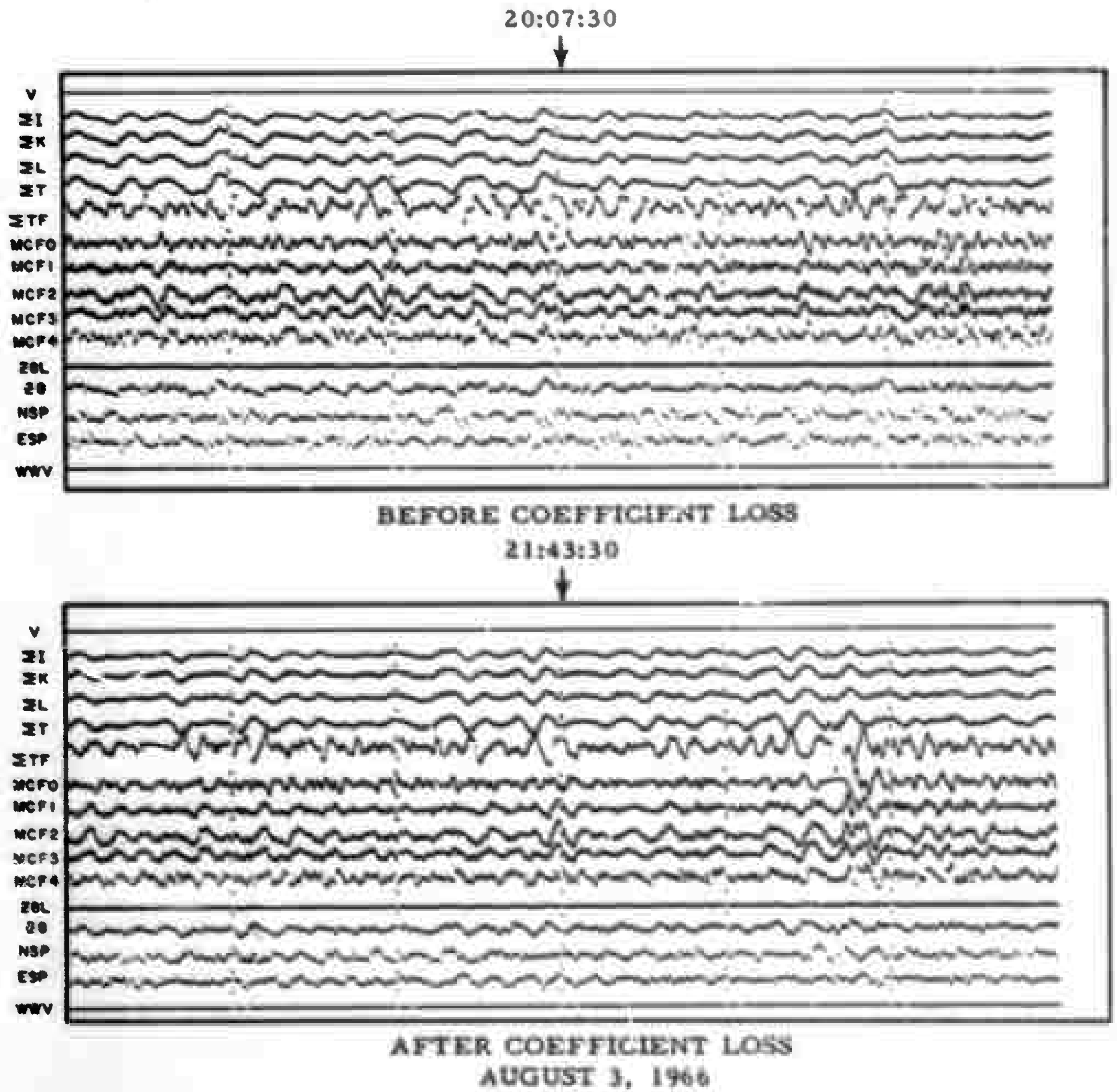


Figure A-6. CPO Secondary Develocorder Records Before and After Coefficient Loss

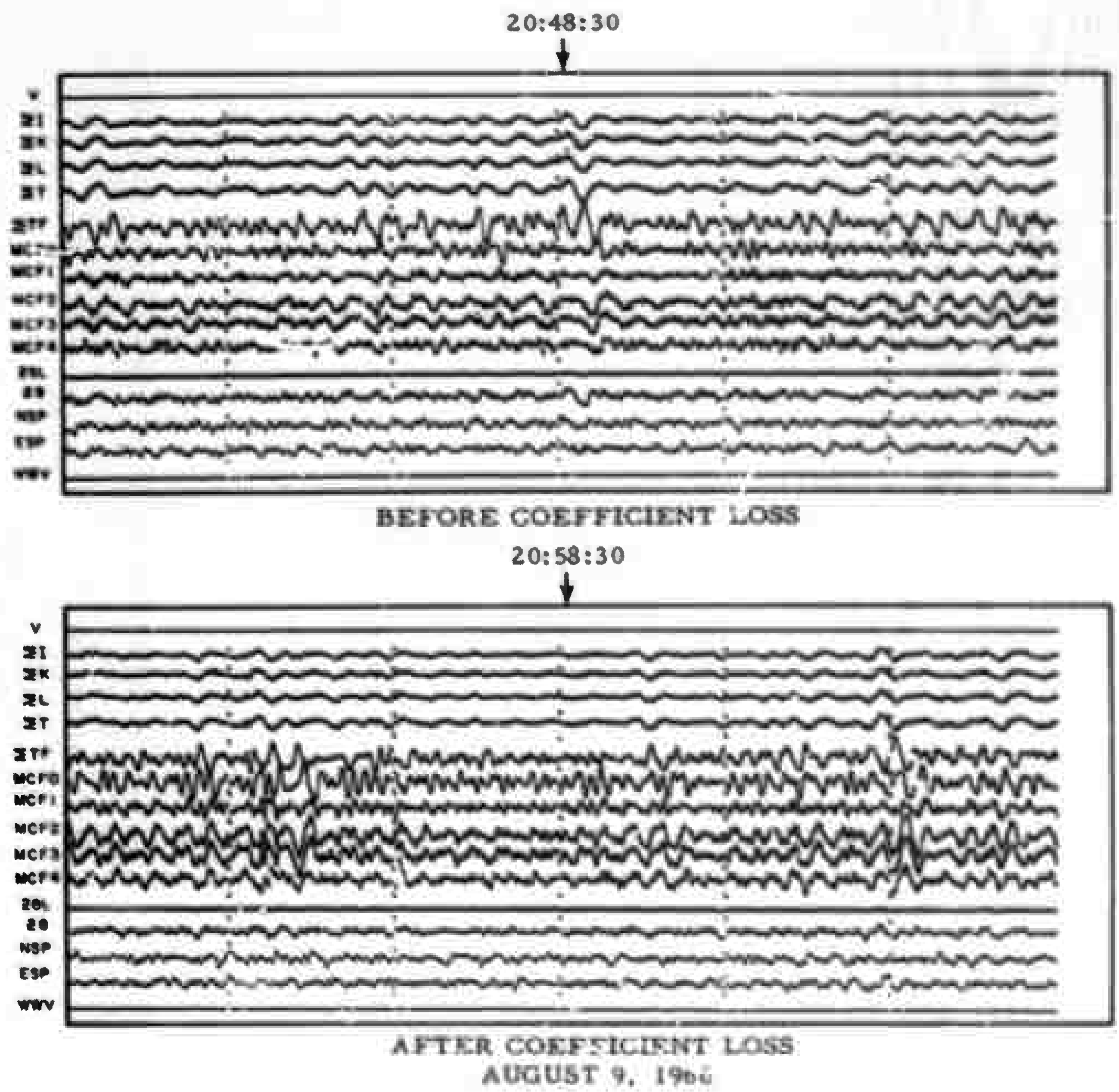


Figure A-7. CPO Secondary Develocorder Records Before and After Coefficient Loss

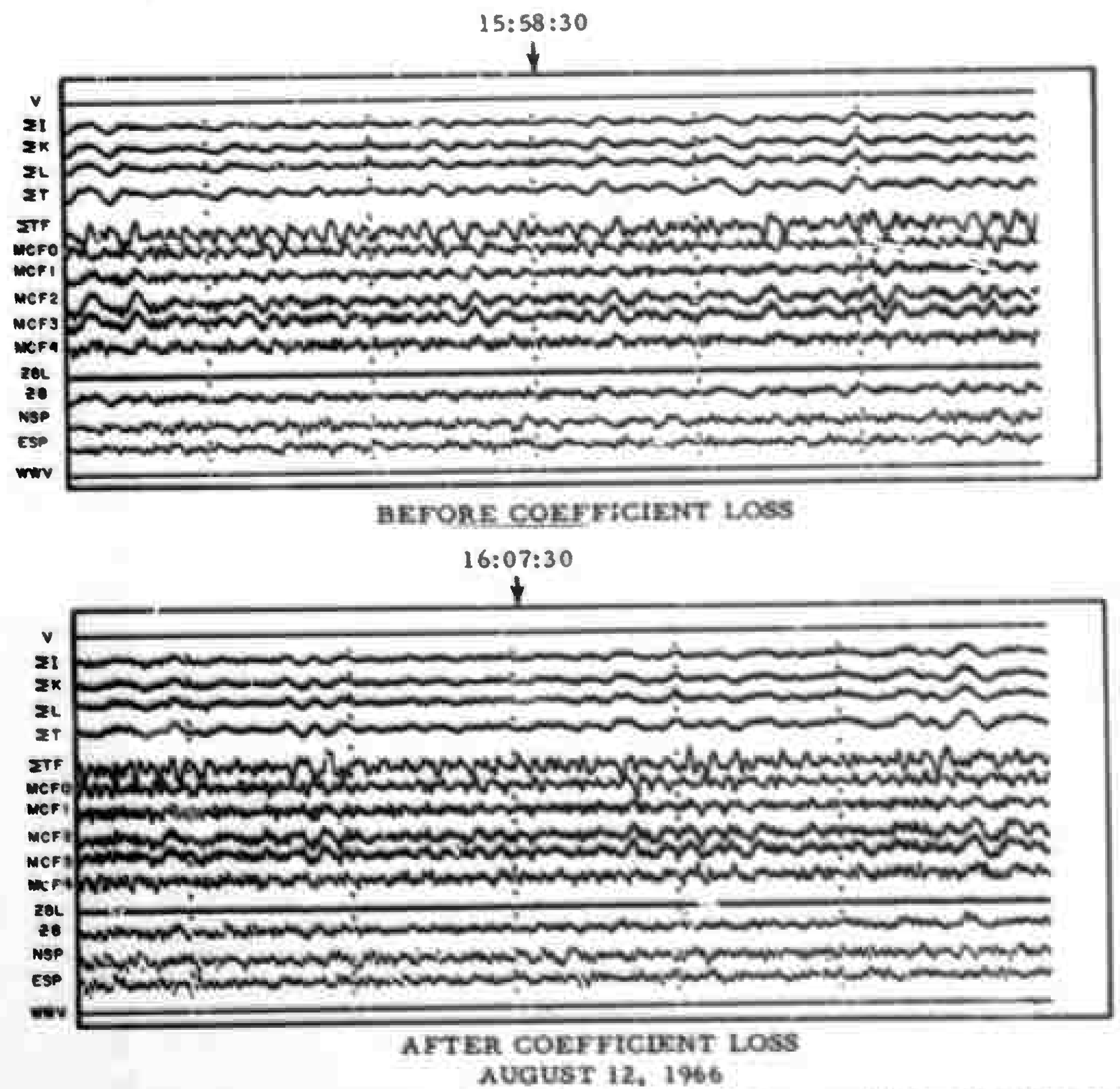


Figure A-8. CPO Secondary Develocorder Records Before and After Coefficient Loss

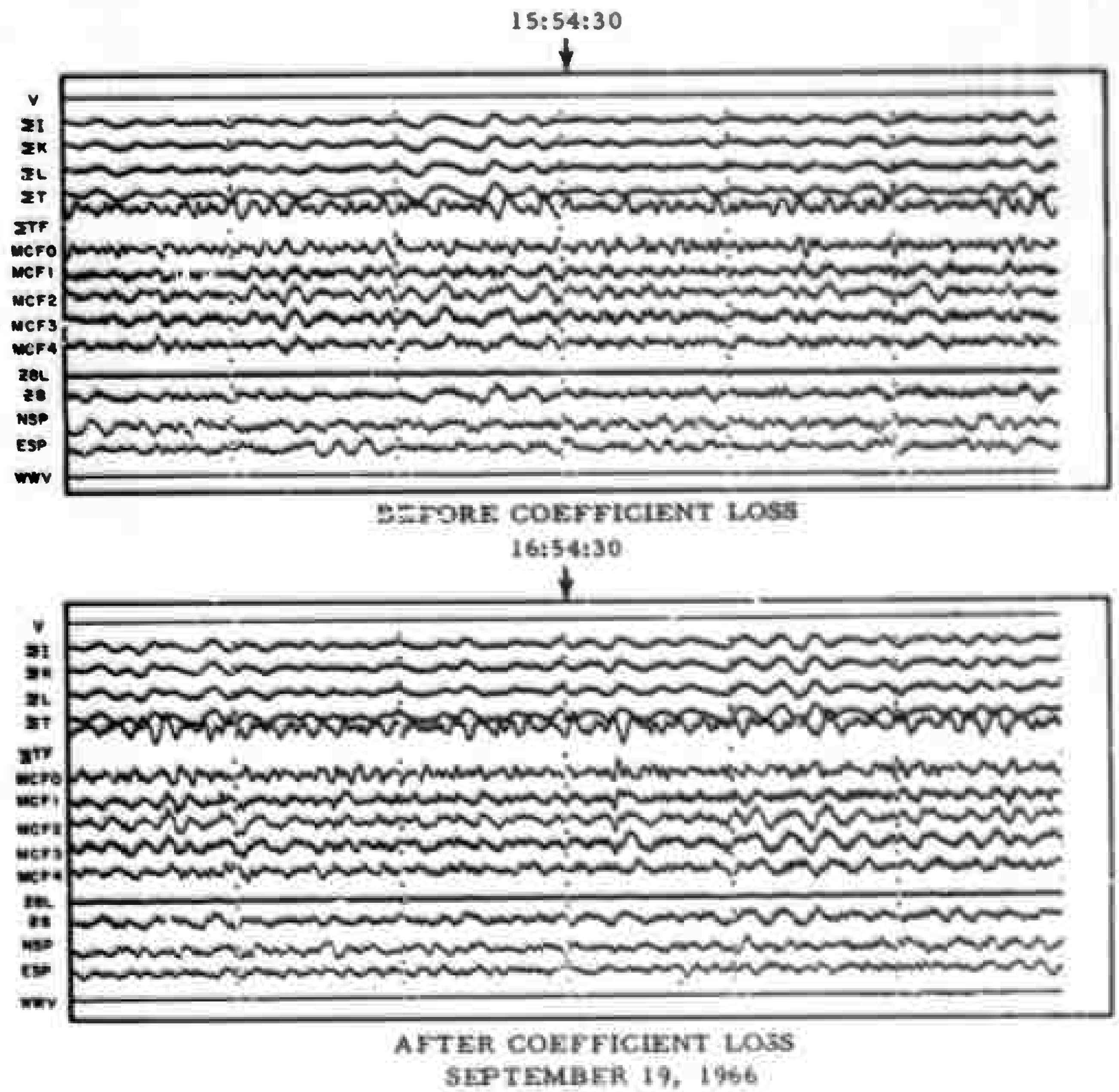


Figure A-9. CPO Secondary Develocorder Records Before and After Coefficient Loss

APPENDIX B

EVENTS RECORDED AT CPO DURING AUGUST 1966

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APPENDIX B

The purpose of this appendix is to present the two lists of events recorded at CPO during August 1966 and discussed in Subsection IIID.

Table 1 presents the events reported without the MCF data and Table 2 presents the events reported with the MCF output.

CPO

AUGUST - WITHOUT PROCESSOR

Table B-1

NUMBER OF EVENTS REPORTED AT CPO WITHOUT DMCF DATA - AUGUST 1966

Date	Arrival Times
August 1, 1966	0238059
	0341354
	0636460
	0746524
	0926382
	0955085
	0959579
	1405210
	1418184
	1447397
	1545295
	1600577
	1601543
	1928137
	2044384
August 2, 1966	0112017
	0115547
	0246575
	0838505
	1608296
	1831481
	2351227
August 3, 1966	0438186
	0812200
	1029000
	1225480
	1228514
	1611341
	1904553
	2143461
August 4, 1966	0037016
	0319217
	0333476
	0500531
	0555415
	0600525
	0603403
	1535230
	2145516
	2204567
August 6, 1966	0242554
	0449304
	0737190
	0753125
	0816406
	0831214
	1446364
	1844451
	1945471
	2032091
	2115297
August 7, 1966	0223137
	0325525
	0336298
	0416390
	0520375
	0530214
	0538363
	0827039
	0841100
	1420048
	1443090
	1741433
	2031385
August 8, 1966	0000487
	0043430
	0134255
	0631440
	0808136
	1008005
	1609555
	1815256
	1842178
	2043462
	2315456

Date	Arrival Times
August 9, 1966	0009419
	0117223
	0125224
	0209374
	0227553
	0346116
	0615029
	0637510
	0903410
	1042282
	1118128
	1254129
	1924240
	2240365
August 10, 1966	0213482
	0514506
	0531028
	1252288
	1301506
	1304105
	1326019
	1534578
	1630564
	1729577
	1754519
	1758316
	2129124
	2135312
	2223458
August 11, 1966	0035037
	0446320
	0526310
	0539025
	0956051
	1017437
	1055592
	1331033
	1452408
	1505055
	1519548
	1621389
August 12, 1966	0027222
	0035500
	0437574
	0931130
	1019350
	1041311
	1445430
	1452405
	2026245
August 13, 1966	0048230
	0410535
	0448191
	0805595
	0905496
	1507455
	1524372
	2142339
August 14, 1966	0545225
	0715333
	0756042
	1004184
	1041000
	1149583
	1349085
	1534004
	2301100
	2309450
August 15, 1966	0230030
	0234035
	0253055
	0304339
	0925475
	1039540
	1107340
	1344426
	1519218
	1700217
	1859382
	1907149
	1945410

Date	Arrival Times
August 16, 1966	0228455
	0230005
	0233295
	0257027
	0302420
	0340513
	0405416
	0448398
	0752587
	1003115
	1505412
	1732536
	1807386
	2004576
	2034525
	2114205
	2343295
August 17, 1966	0539327
	0548477
	0556443
	0629258
	0632486
	1214063
	1359577
	1425513
	1519192
	1629100
	1750338
	2012263
	2015172
	2024003
	2109440
	2313040
	2322340
August 18, 1966	0024436
	0027578
	0201273
	0340302
	0620054
	0648515
	0746050
	0920416
	1038036
	1108482
	1122326
	1205409

Date	Arrival Times
August 18, 1966	1338262
	1453000
	1453148
	1456410
	1601337
	1740110
	1945375
August 20, 1966	0027587
	0041552
	0130019
	0340184
	0347268
	0353319
	0640120
	0750467
	0945189
	1002170
	1053286
	1112450
	1150500
	1206459
	1212109
	1214456
	1217065
	1253414
	1611122
	1759120
	2313130
	2319301
	2325120
August 21, 1966	0035005
	0143068
	0315050
	0517400
	0519245
	0651447
	0835452
	0856582
	0946437
	1414211
	1917052
	2011204
	2139553

Date	Arrival Times
August 22, 1966	0758355
	0832324
	1118425
	1119429
	1432322
	1710554
	1721144
	1740370
	1800450
	1838440
	2158242
	2303000
	2317134
August 23, 1966	0143430
	0145319
	0300590
	0356359
	0404009
	0617409
	0646377
	0655273
	0822043
	1514378
	1924110
August 24, 1966	0047507
	0101100
	0215578
	0530200
	0646527
	0726563
	1054485
	1059340
	1218266
	1548596
	2017054
August 25, 1966	0750120
	0810225
	1101195
	1209224
	2328456

Date	Arrival Times
August 26, 1966	0025455
	0110249
	0121471
	0315550
	0606295
	0847120
	1028481
	1409040
	1446142
	2203229
	2303536
August 27, 1966	0022538
	0107598
	0255255
	0454439
	0457552
	0543500
	1216540
	1511553
	1551183
	1525556
August 28, 1966	0135013
	0202005
	0423403
	0429594
	0504203
	0743473
	0748006
	0751142
	1017100
	1020582
	1031205
	1340030
	1456541
	1907066
	2044281
	2249598

Date	Arrival Times
August 29, 1966	0551512
	0555565
	0557414
	0815618
	1340390
	144029[illegible]
	1740229
	1937170
	2001216
	2112078
	2239081
August 30, 1966	0102327
	0314415
	0534337
	0623381
	0933383
	1259185
	1349340
	1653575
	1812596
	2029160
	2340005
	2342432
August 31, 1966	0240048
	0249130
	0328434
	0442164
	0646300
	0836121
	0849056
	0907435
	0958110
	1005406
	1545117
	1825035
	1950409

CPO

AUGUST - WITH PROCESSOR

Table B-2

NUMBER OF EVENTS REPORTED AT CPO
WITH DMCF DATA - AUGUST 1966

Date	Arrival Times
August 1, 1966	0241042
	0341353
	0352135
	0410258
	0619462
	0636457
	0746518
	0926380
	0955085
	0959578
	1405179
	1418181
	1447390
	1545294
	1600577
	1601543
	1928138
	2044378
	2121303
	2214419
	2351028
August 2, 1966	0008306
	0043087
	0112017
	0115550
	0246075
	0838504
	0858363
	0933485
	1608298
	1719503
	1816419
	2341057
	2350075
August 3, 1966	0438172
	0551090
	0812196
	0942107
	1028593
	1128045
	1202297
	1225481
	1228514
	1510011
	1611381
	1724165
	1904548
	2143462
August 4, 1966	0024527
	0037014
	0319215
	0333463
	0337402
	0349095
	0356076
	0358478
	0423299
	0455553
	0500520
	0536301
	0555413
	0600520
	0603361
	0609402
	0855401
	1535234
	1913269
	2045516
	2204566
	2338115
	2344591

Date	Arrival Times
August 5, 1966	0038366
	0059542
	0109578
	0122009
	0127175
	0411161
	0414132
	0438350
	0451360
	0502192
	0515239
	0834034
	0950181
	1031351
	1108112
	1131578
	1325459
	1601463
	1739306
	1829237
	2015092
	2249107
August 6, 1966	0231024
	0242549
	0350354
	0410565
	0442140
	0449302
	0519422
	0557080
	0603466
	0737185
	0744529
	0753119
	0816406
	0831200
	1317051
	1414578
	1446365
	1453226
	1844452
	1945568
	2032038
	2115296

Date	Arrival Times
August 7, 1966	0102127
	0223138
	0325538
	0336298
	0416389
	0520375
	0530214
	0538357
	0827037
	0841141
	1243119
	1420044
	1443026
	1741408
	1846538
	2031381
	2309043
August 8, 1966	0000480
	0043430
	0134255
	0148320
	0412208
	0631440
	0638194
	0732130
	0808138
	0832548
	0859215
	1008005
	1155399
	1358042
	1402096
	1609550
	1815256
	2043402
	2315456
August 9, 1966	0009419
	0117238
	0209352
	0227551
	0346117
	0615025
	0637532
	0903410

Date	Arrival Times
August 9, 1966	1042281
	1118129
	1254119
	1924241
	2240364
August 10, 1966	0513482
	0514506
	0531013
	1252288
	1301533
	1304104
	1326018
	1350286
	1534579
	1630563
	1729578
	1754511
	1758316
	2129123
	2135302
	2223484
August 11, 1966	0018205
	0035505
	0446261
	0500521
	0526227
	0538574
	0623194
	0753307
	0927157
	0955593
	1017376
	1055546
	1236057
	1331067
	1452349
	1505056
	1519549
	1621388
	1902594
	2356128
October 12, 1966	0035492
	0115535
	0418010
	0718253
	0931126
	0941236
	1019349
	1041311
	1044323
	1445427
	1452397
	1613580
	2026244
	2153547
October 13, 1966	0048236
	0216425
	0410530
	0448132
	0520550
	0535087
	0740377
	0805591
	0905496
	1106448
	1507456
	1512367
	1524371
	1552036
	2100459
	2142340
October 14, 1966	0545224
	0715334
	0756039
	1004178
	1022080
	1040596
	1149581
	1349084
	1614255
	2301101
	2309445

Date	Arrival Times
August 15, 1966	0230026
	0234091
	0244476
	0253062
	0304340
	0317509
	0347591
	0432386
	0446548
	0535111
	0610531
	0925471
	1019337
	1039538
	1107337
	1111196
	1121333
	1344417
	1519216
	1700217
	1859280
	1907141
	1945406
August 16, 1966	0228452
	0230049
	0233295
	0257019
	0302420
	0340506
	0405410
	0448398
	0635117
	1003114
	1434320
	1505408
	1718277
	1807386
	2004575
	2034521
	2114207
	2343294
August 17, 1966	0036110
	0054453
	0120359
	0539328
	0548473
	0556440
	0629258
	0632486
	1214059
	1359578
	1425512
	1519192
	1629102
	1750328
	2012250
	2015172
	2023595
	2027522
	2109446
	2240057
	2313041
	2322341
August 18, 1966	0024429
	0027596
	0105346
	0128519
	0243127
	0404005
	0620045
	0648513
	0746118
	0920419
	0934000
	1038037
	1108495
	1122324
	1205405
	1214465
	1338261
	1452589
	1455451
	1601327
	1740108
	1744462
	1945392

Date	Arrival Times
August 19, 1966	0036191
	0135542
	0153167
	0306546
	0318148
	0355083
	0406162
	0415471
	0419491
	0518172
	0743021
	0815102
	0821433
	1056442
	1132598
	1235122
	1259483
	1328107
	1329272
	1359450
	1407275
	1430563
	1703020
	1854222
August 20, 1966	0027586
	0041552
	0130066
	0340186
	0347266
	0353310
	0640088
	0724334
	0750467
	0813103
	0822161
	0827136
	0945189
	1002183
	1010454
	1053283
	1112449
	1150498
	1206456
	1212106
	1217065
August 20, 1966	1253413
	1611122
	1715463
	1759135
	2308585
	2319299
	2325142
August 21, 1966	0035005
	0143061
	0315052
	0443340
	0517417
	0519237
	0651446
	0835444
	0856580
	0946438
	1030318
	1414216
	1912076
	1914231
	2011200
	2139547
	2253271
August 22, 1966	0528465
	0735172
	0758354
	0832349
	1118424
	1119429
	1145516
	1326152
	1432318
	1450518
	1527145
	1546383
	1651522
	1710550
	1721143
	1734276
	1740372
	1800425
	1821149
	1838433
	2158229
	2240132
	2303007
	2317134

Date	Arrival Times
August 23, 1966	0023336
	0132017
	0143432
	0145318
	0300590
	0356355
	0404010
	0612409
	0648154
	0655273
	0822219
	1051261
	1514377
	1924116
August 24, 1966	0047506
	0101098
	0215576
	0348199
	0530196
	0646524
	0726563
	0857258
	1059340
	1107586
	1113525
	1218266
	1548593
	1559327
	1623137
	1934236
	2017056
August 25, 1966	0623523
	0738010
	0750119
	0810224
	1101194
	1209220
	1940124
	1948154
	2328455
August 26, 1966	0025451
	0110241
	0121464
	0315542
	0415313
	0457248
	0606294
	0644560
	0829008
	0841432
	0847120
	0926219
	1028482
	1211297
	1409039
	1446136
	1604513
	2203186
	2303534
August 27, 1966	0107597
	0246230
	0255249
	0437595
	0454434
	0457545
	0543497
	0834131
	1018415
	1216498
	1511548
	1525556
	1551181
	1805070
	1947335
August 28, 1966	0135013
	0141455
	0202005
	0211538
	0230257
	0423399
	0429589

Date	Arrival Times	Date	Arrival Times
August 28, 1966	0504206	August 30, 1966	0102326
	0520278		0157456
	0743467		0328007
	0748002		0508189
	0751210		0534357
	0758498		0623421
	0800555		0833097
	1017096		0933381
	1238148		1259204
	1252536		1349341
	1310431		1653575
	1340033		1813009
	1456540		2029159
	1605022		2342430
	1907063		
	2044296	August 31, 1966	0137098
	2249596		0240257
	2252577		0249128
			0316570
August 29, 1966	0131307		0328434
	0201583		0442148
	0239445		0642410
	0401335		0836121
	0551512		0849052
	0557418		0907163
	0704147		1005407
	0815020		1113072
	0837135		1212345
	1222011		1545122
	1340389		1703159
	1436567		1825034
	1440289		1950409
	1712369		
	1740224		
	1937178		
	2001208		
	2112010		
	2239076		